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Breeding for Disease and Insect Resistances in Keng Rice[1]

Chen-seng Huang[2]

Abstract: Tainung 67 was crossed with Tetep, Carreon, Dawn and other donor parents followed by 3 to 4 consecutive backcrossings to Tainung 67 for improving its blast resistance. A genetic study on the BC_1F_1's revealed that Tetep was most numerous in the genes resistant to 4 races of the blast fungus tested. An upland blast nursery with corn border lines facilitated the screen-testing of breeding lines. Many new selections from this breeding program were resistant to the blast disease and outyielded Tainung 67. Tainung 67 was also crossed with yellow dwarf resistant Firooz, followed by 2 consecutive backcrossings to Tainung 67. From the segregating progenies of these backcross hybrids, 11 new strains resistant to yellow dwarf were selected. The yields of 2 strains surpassed that of Tainung 67. The brown planthopper resistance of a *Oryza rufipogon* was transferred to Ponlai by 2 consecutive breeding programs. TNGY8849, a final selection that was resistant to blast and brown planthoppers, is being recommended for registration. Various other varieties possessing *Bph 1*, *bph 2*, *Bph 3* and *bph 4* were also crossed with Tainung 67, followed by 2 consecutive backcrossings. The resistant strains selected from the segregating materials of these hybrids are being tested in the preliminary yield trial. Several *japonica* cultivars showed resistance in a test for white-backed planthopper resistance, including moderately resistant Tainung 67. A breeding program and the genetic study related with the resistance are in progress. Twenty-one double cross F_1's between the lines selected mostly from the above mentioned backcross breeding programs were subjected to anther culture cooperated with tissue culturists. A total of 1,567 green AC_1 plants derived from the anther culture gave only 230 diploid AC_1S_1 lines for screen-testing. The rate of this diploid recovery was greatly improved later. Segregation patterns of blast, planthopper resistances and shattering habit of rice grains among the AC_1S_1 lines showed that the combination of different desirable traits by double crossing followed by anther culture will be successful and readily useful.

Introduction

Rice surplus, a headache problem in recent years, in Taiwan has been so far encouraged by rice prices of official purchase, successful rice improvement work and a

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dropping of the per capita consumption of rice. The result is that our government has to put this rice into export at prices of around $200 a ton or slightly more, that eventually cost the government about $650 a ton (1). Inevitably a large amount of deficit accumulates by this official purchase and sale. Moreover the export dumping provokes the U. S. to claim for a necessity to limit our rice export (2). One of the remedies for solving this problem will be to reduce the rice area and to cut down the cost of rice production. Our government is now making efforts in converting rice field to dryland cropping and to reduce rice by the PIK policy. For reducing furher the cost of rice production, a sharp expansion in the size of rice farming and a simplification of mechanized rice culture are needed. Our farmers spend about NT$1,000 million a year to buy the chemicals for controlling the blast disease and planthoppers (24). Needless to say, the use of resistant varieties is the most economical means for their controls. It not only reduces the cost of rice prodution but also control diseases and insects without any adverse side-effect resulting from the application of agricultural chemicals. The results of our efforts on this lines of work are reported below.

Materials and Methods

Breeding for blast (BL) disease resistance

Tetep, Dawn, Carreon and Dular were used as the sources of BL resistance in a backcross breeding program, for which Tainung 67 served as the recurrent parent. We repeated the backcrossing 3 to 4 times. The BC_1F_1's of these cross combinations were tested for the resistance against four races of the blast fungus, ID-14, IE-2, IF-3 and IG-2 that attacked Tainung 67 for a genetic study and selection. In the following BC generations, we alternatively used the Kuoshin BL nursery and the artificial inoculation of the composity blast fungus for testing the resistance. Other sources of BL resistance were also used such as Fujihikari, Toyonishiki, Sensho, Pi-lines, BL-lines, Tainung 62 and Tainan 6 that belonged to *japonica*, and IR34 to IR50, various IR-lines, Taichung sen 3, 10, Tainung sen 12, Seweon 290, M1-48, Ta-poo-chu-z and Chu-z belonging to *indica*. We crossed these varieties with Tainung 67, and the F_1's were backcrossed to Tainung 67 once without any further backcrossing. The ordinary pedigree method was followed in propagating and selecting these hybrid materials. An upland blast nursery with corn border lines was established about one month after the transplanting of both rice crops for testing breeding lines mostly of later segregating generations. We also sent a number of advanced lines to the Chiayi AES/TARI and the IRRI, Philippines for BL test, so that the lines resistant to a broader range of pathogen could be selected. From each of the advanced line that showed a certain degree of uniformity, mostly at the BC_1F_4 or BC_3F_3 or BC_4F_3 or later generations, we selected 3 to 5 individuals per line and bulked their seeds to establish a strain for yield testing. The ordinary replicated field plots were employed in the yield test.

Breeding for resittance to yellow dwarf and other diseases

Cultivar Firooz provided the source of yellow dwarf resistance to be introduced into Tainung 67 by backcross breeding. The F_1 between Tainung 67 and Firooz was back-

crossed to Tainung 67 two times. The segregating materials of BC generations were inoculated with *Nephotettix* leaf hoppers carrying the pathogen for discarding yellow dwarf susceptible plants. We used the pedigree method after the BC_2F_1, and 11 strains were finally selected for yield trials.

For selecting the lines resistant to the bacterial leaf blight disease, we generally inoculated our breeding materials by clipping method with the Academia Sinica's isolate No. 604 of the bacterium. The sources of resistance used were TKM-6, DV85, various IR lines, Wase-aikoku, Tainan 6, Koshihikari and other *japonica* varieties.

Breeding for planthopper resistance

The F_1 between a Tainung 61 semidwarf mutant and a wild rice, *Oryza rufipogon* (IRRI Acc. No. 100923) was backcrossed to the mutant 2 or 3 times to transfer the brown planthopper (BPH) resistance. We selected the BPH resistant lines from these hybrid materials, and crossed them with 2 BL resistant *japonica* cultivars. After a series of propagation and selection on these hybrid materials, various strains resistant to BL and BPH were established, and 7 strains of them reached the final selection after the yield trials in the replicated field plots. They were thus entered in the regional yield tests at 7 sites in the island for one year. They also received the BL test at several BL nurseries including those at Chiayi AES and IRRI, Philippines for about 3 years.

The BPH resistance sources in cultivated rice were also used as the donor parents, they were Chianung yuh 243 and other varieties that possessed *Bph 1*, Tainung sen 12 and others having *bph 2*, Rathu Heenathi and others possessing *Bph 3* and Babawee of *bph 4*. We backcrossed the F_1's between Tainung 67 and these donor varieties to Tainung 67 two times and selected their progenies for BPH resistance according to the pedigree method.

For the white-backed planthopper (WBPH) resistance, we tested first of all a number of *japonica* cultivars with seedbox technique to identify the *japonica* resistance sources. Then crosses were made between the resistant cultivars with other varieties for breeding purposes and a genetic study.

Application of anther culture to varietal improvement of japonica rice

The F_1's of 21 *japonica* crosses, mostly the double crosses between lines selected from backcross breeding, were used as the materials for anther culture. At seedling stages, we subjected these F_1's to a blast test to eliminate the blast susceptible plants. The tissue culture laboratory, TARI undertook anther culture of the remaining resistant F_1 plants, when their young panicles reached the meiosis stage. "AC_1" denotes hereafter the plants from the first time of anther culture and "AC_1S_1" their progenies from the first selfing.

The AC_1 seedlings produced by the tissue culture laboratory were transferred to the breeder for the subsequent growth and selection. We selected only the diploid plants and discarded the haploid, tetraploid and other undesirable plants. Several seed samples were taken from each of the selected AC_1 diploid plants to provide the seed for testing the BL, BPH and WBPH resistances and agronomic performances of their progenies or

AC_1S_1's. A progeny consisted of 60 plants that were individually spaced. At harvest, we bulked seed of 5 to 6 plants from each of the selected lines that showed an acceptable degree of uniformity to establish a strain for replicated yield trials.

Results and Discussion

1. Breeding for blast disease resistance

In the past

Since the beginning of commercial cultivation of Ponlai rice in Taiwan, the blast disease has been a serious problem (4). In the past 30 years, efforts were made to breed blast resistant varieties by our breeding stations, supported by several sophisticated research projects such as irradiation experiment (4), development of multiline varieties resistant to different races of the fungus (13, 15) and genic analyses of the resistance against different races of the pathogen (17). A large number of resistant varieties were developed during this period, such as Kwan-fu 1 and 401, Chianung 242, Taichung 181, 186, Kaohsiung 137, 138, 141, and highly resistant Tainan 6 and Tainung 62. Most of these varieties did not received much popularity from farmers, or their resistances did not last long. More than 90% of the blast resistant varieties that were registered received the source of resistance from a single variety, Litchi-hung, which is known to possess the resistance gene of *Pi-k* alleles (11). A narrow range of resistance germplasm used, inadequate testing technique for the resistance and the rare use of

Table 1. Occurrence of leaf (LBL) and panicle (PBL) blasts in Tainung 67 and Tainan 5 (in parenthesis) at five disease nurseries.

Type	Year	Chuanwei	Chushan	Chiayi	Wanluan	Kuanshan	Ave.	Upland nursery
LBL	1976	3(4)*a*	4(4)	5(5)	3(4)	5(5)	4(4)	5(5)
	1979	8.7(6.8)	7.9(5.4)	8.8(7.3)	7.5(6.5)	8.0(7.8)	8.2(6.8)	9.0(8.0)
	1980	9.0(9.0)	9.0(8.1)	7.5(5.0)	6.6(8.2)	9.0(8.9)	8.2(7.8)	9.0(9.0)
	1981	9.0(9.0)	8.3(7.8)	8.0(6.0)	6.0(4.6)	8.5(5.1)	8.0(6.5)	9.0(9.0)
	1982			8.0(5.5)		8.0(8.0)	8.0(6.8)	9.0(9.0)
	1983			8.5(7.0)		8.0(5.5)	8.3(6.3)	8.5(7.5)
	Ave.	7.4(7.2)	7.3(6.3)	7.6(6.0)	5.8(5.8)	7.8(6.7)	7.4(6.4)	8.3(7.9)
PBL	1976	1(2)	1(1)	D(5)	2(4)	D(D)	1(3)	
	1979	D*b*-(5)	9(9)	D(7)	9(9)	D(7)	9(7)	
	1980	—(—)	—(—)	7(5)	9(9)	—(—)	7(7)	
	1981	9(9)	9(7)	7(9)	7(7)	7(3)	9(7)	
	1982			6.0(8.0)		1.0(—)	3.5(8)	
	1983			8.0(7.0)		4.0(3.0)	6(5)	

a; 0=HR, 1=R, 3=MR, 5=MS, 7=S, 9=HS. b, D=Dead due to LBL.

backcross breeding method were the probable causes leading to the above consequence, although the breakdown of resistance due to the change of pathogenic races could not be neglected.

In the meantime, Tainung 67 that was supposed to receive the semidwarf plant type from Taichung Native 1 and released in 1978, showed a breakthrough in the ceiling yield potential and other desirable traits (14). Its cultivated area expanded with an unprecedented manner, reaching more than 70% of the total rice area of Taiwan in 1982 (3). This variety is slightly more susceptible to the blast disease when compared with Tainan 5, the most leading variety before Tainung 67. This is shown by the results obtained in the 6-year uniform blast nurseries (Table 1). The blast disease occurred in Tainung 67 has been so far controlled by fungicides that cost farmers in Taiwan about NT$300 million a year (1981) (34). Therefore, it is most urgent to introduce blast resistance into Tainung 67, which is known to be susceptible to 4 among 10 races of the fungus tested (Table 2). Among these 4 races, IG-2 has been one of the two races that were found most common in the island in recent years. Another commonest race is II-1, to which Tainung 67 is resistant. II-1 together with IG-2 accounted for 90% of the total isolates collected in the island during 1974-1977 (27).

Table 2. Reaction of rice variety Tainung 67 to different races of the blast fungus (Institute of Botany, Academia Sinica).

Race	Reaction of Tainung 67
I C - 18	R
I C - 26	R
I D - 14	S
I E - 2	S
I F - 3	S
I F - 4	R
I G - 2	S
I H - 1	R
I I - 1	R

Backcross breeding to Tainung 67

A backcross breeding program was initiated in the 1979 second rice season to introduce the blast resistances of Tetep, Carreon, Dawn, Dular, Sensho, TKM-6, and M_1-48, into Tainung 67. No further backcrossing was made for the crosses related with Sensho, TKM-6 and M_1-48 after the BC_1.

In the 1980 second crop, the BC_1 plants of Tainung 67^2/Dawn, Carreon, Tetep crosses were inoculated with four races of the blast fungus, ID-14, IE-2, IF-3, and IG-2, that attacked Tainung 67. The Institute of Botony, Academia Sinica prepared the spore suspensions for this test. We made 4 wounds on each of three leaves per BC_1 plant by rubbing with a used ball-pen tube and spot-inoculated on them with the four races of the fungus. The inoculated leaves were covered with a plastic bag. Any plant that produced the conspicuous lesion on one or more of the three leaves is considered susceptible. We completed this test before the flowering of the plants and selected the plants resistant to all four races for the second backcrossing.

The segregations of leaf blast resistance in the above test in the BC_1F_1's of Tainung 67^2/Dawn, Carreon, Tetep crosses are shown in Table 3. Based on the patterns of

segregation, it is concluded that the resistance of Dawn to races ID-14 and IG-2 seems to be controlled by a single dominant gene, to race IE-2 by 3-4 pairs and to race IF-3 by 2-3 pairs of genes. The resistance of Carreon against races ID-14 and IG-2 seems to be controlled by a single dominant gene and to IE-2 and IF-3 by 3-4 pairs of genes. It seems that more resistance genes were involved in the Tetep cross; for example to races ID-14 and IG-2, the Tetep's resistance seems to be controlled by two pairs of genes and to races IE-2 and IF-3, 4-6 pairs of genes seem to be involved (Table 3). Therefore, We laid more emphasis on the hybrid materials related with Tetep in the following backcrossings.

Table 3. Segregation of leaf blast resistance in the BC_1F_1's of $TNG67^2$/Dawn, Carreon, Tetep to 4 races of the blast fungus (1980 2nd crop).

Combination	Race	R	S	Possible ratio $p(X^2)>5\%$	Possible Gene pairs
$TNG67^2$/Dawn	I D—14	13	18	1 : 1	1
	I E— 2	28	3	7 : 1, 15 : 1	3, 4
	I F— 3	25	6	3 : 1, 7 : 1	2, 3
	I G— 2	13	18	1 : 1	1
$TNG67^2$/Carreon	I D—14	21	34	1 : 1	1
	I E— 2	49	6	7 : 1, 15 : 1	3, 4
	I F— 3	49	6	7 : 1, 15 : 1	3, 4
	I G— 2	21	34	1 : 1	1
$TNG67^2$/Tetep	I D—14	28	12	3 : 1	2
	I E— 2	38	2	15 : 1, 31 : 1, 63 : 1	4, 5, 6
	I F— 3	39	1	15 : 1, 31 : 1, 63 : 1	4, 5, 6
	I G— 2	29	11	3 : 1	2

The BC_2F_1 families of Tainung 67^3/Dawn, Carreon, Tetep crosses were grown in the 1981 first crop at Kuohsin nursery located in a valley of Nantou prefecture, where serious blast occurs every year. The segregation patterns of the blast resistance varied greatly from family to family. Continuous segregation of the resistance appeared most frequent in the Tainung 67^3/Tetep cross, although discontinuous segregation occurred in all three crosses tested. The resistant BC_2F_1 plants that exhibited a plant type close to Tainung 67 were replanted in a pot and taken back to the institute for the third backcrossing.

We grew a half of the seedlings of each BC_3F_1 family in a seedling box and artificially inoculated them with the spore suspension of the composite blast fungus in the 1981 second crop season. Another half of the seedlings were planted in an ordinary breeding nursery without any artificial inoculation. The results of leaf blast test on the

Table 4. Segregation of LBL resistance in the BC_3F_1 and BC_4F_1 of different rice crosses.

BC_3F_1 Cross	R>S	R=S[a]	R<S	Total families	BC_4F_1 Cross	R>S	R=S[a]	R<S	Continuous segregation	Total families
TNG67[4]/Dawn		2	3	5	TNG67[5]/Dawn		4	2		6
TNG67[4]/Carreon	1			1	TNG67[5]/Carreon		2			2
TNG67[4]/Tetep		16	7	23	TNG67[5]/Tetep	3	48	3	4	58
TNG67[3]/Dular		8		8	TNG67[4]/Dular	3	15	1	2	21
Total familes	1	26	10	37	Total	6	69	6	6	87
Source of inoculum	Inoculated with the fungus from various locations				Source of inoculum	At Kuohsin BL nursery				
Year and season	1981 2nd crop				Year and season	1982 1st crop				

a: Based on 1 : 1 x^2-test.

BC_3F_1's are shown in Table 4. The number of one-to-one segregating families tended to increase when one more time of backcrossing was added. Artificial selection was practiced during the heading stage of inoculated BC_3F_1's to pick up the resistant plants having a plant type resemble to Tainung 67. They were thus backcrossed to Tainung 67 the fouth time.

In the 1982 first crop, we tested three groups of materials at the Kuohsin nursery. They were the BC_4F_1's, the BC_3F_2's screened after BL test and without BL test at the BC_3F_1's as mentioned above. The results obtained from the BC_4F_1's are shown in Table 4. Among 87 BC_4F_1 families, 79.3% segregated the resistant and susceptible plants in a ratio of 1:1. In the BC_3F_2 populations, of which BC_3F_1's were disease-tested and screened, 90.2 % were found to segregate a half or more number of resistant plants in a population, while only 50.0% of those BC_3F_2 populations without blast-test at the BC_3F_1 segregated such resistant plants. A large number of blast resistant plants having a

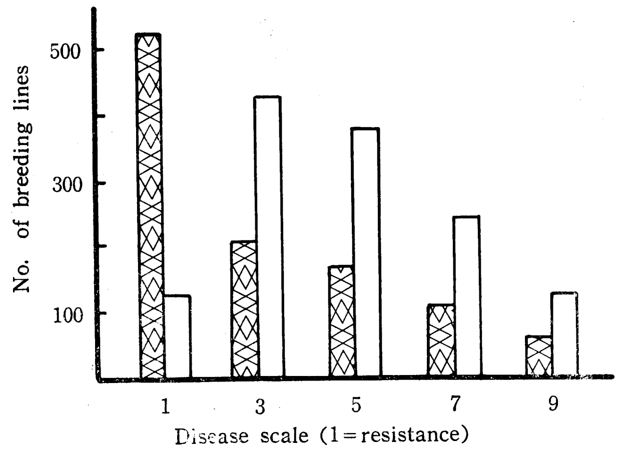

Fig. 1. Comparison of the BL resistance between 1983-II (shaded) and 1983-I crop breeding lines at upland disease nursery with corn border lines.

plant-type resemble to Tainung 67 were selected from the BC_4F_1's and BC_3F_2's at Kuoshin nursery for continuous propagation and screening.

Use of other sources of blast resistance

For using a wide range of blast resistance germplasm, we also crossed Tainung 67 with two groups of rice varieteis. The first group was the blast resistant *japonica* varieties, including Fujihikari, Mutsunishiki, Toyonishiki, Sensho and those Pi-lines and BL-lines developed by Japanese, Tainung 62 and Tainan 6, etc. This group of rice generally has a better rice quality and the blast resistance mostly from their *indica* ancestors. The second group included various IR strains from IR34 to IR50 and to IR 21916 or IR21931 etc., and other *indicas* like Tainung Sen 12, Taichung Sen 3, 10, Suweon 290, M_1-48, Ta-poo-chu-z and Chu-z etc.

The F_1 hybrids from the above crosses were backcrossed to Tainung 67. The pedigree method was followed without further backcrossing in the following generations to propagate and select the segregating materials. The bulk method using rice transplantor was also employed for the advancement of generations. We conducted the blast test at later segregating generations of these materials, when the upland blast nursery with corn border lines was available. Generally speaking, the plant types and rice quality of these segregating hybrids were poor when compared with those received more backcrossings. Therefore, only 30 lines of *japonica* source and 43 lines of *indica* source reached the preliminary yield trial.

Upland blast nursery with corn borderlines

For screening a large number of breeding lines for blast resistance it is necessary to have a stable but severe disease nursery every rice season. The disease occurs most at 21°-22°C minimum day temperatures and a dew period of 6 or more hours per day (25). We produced this environment by setting the disease nursery in April-May (1st crop) and September-October (2nd crop) and covering the plant seedlings with a plastic sheet at night protected with corn borderlines. As for other nursery managements, such as fertilizer application, irrigation, inoculation etc, we followed the methods used in the ordinary blast nursery. The results were very successful, even in the second rice season severe blast disease occurred without exception.

We started to test our breeding lines in this blast nursery in the 1982 second rice season. The blast resistances of the 1983-I and 1983-II breeding lines were compared in Fig. I. The resistant lines in the 1983 second crop increased drastically after the selection based on the results of blast test conducted in the 1983 first crop.

Yield trial of blast resistant new strains

Since the BC_3F_3 lines from the backcross breeding and the BC_1F_4 or BC_1F_5 lines from other crosses reached an acceptable uniformity for agronomic traits in the 1982 second crop, we bulked seed of the individuals within lines to establish strains for a preliminary yield trial. A total of 165 strains including those blast resistant were tested in the replicated yield trial in the 1983 first crop. In the following season, 56 strains of them got into the advanced yield trial, and a new set of 126 strains were tested in replicated plots for the preliminary yield trial. The number of entries and their donor parents of

resistance are shown in Table 10 with those strains resistant to insects. The agronomic performaces of some BL resistant elites are shown in Table 5. Many of these entries gave a grain yield similar to or higher than Tainung 67 and were resistant to blast disease, although we do'nt know how many resistance genes were involved in different strains, or how long the resistance will last. We recommended TNGY 148 to be participated in the regional yield test of Ponlal rice starting from the 1984 first crop.

Table 5. Examples of new blast resistant strains of rice having different sources of resistance.

TNGY NO.	Cross	1st crop			2nd crop			LBL	PBL
		Yield (kg/ha) (%)	DFTH-a	Pl. hgt. (cm)	Yield (kg/ha) (%)	DFTH-*a*	Pl. hgt. (cm)		
99	TNG67^4/Tetep	8,333(105)	93	107	4,573(91)	65	110	1(R)	R
101	TNG67^4/Tetep	8,500(107)	93	110	4,563(91)	67	108	3(MR)	MR
148	TNG67^2/Fujihikari	8,296(104)	84	112	6,727(134)	57	111	1(R)	R
667	TNG67^4/Dawn	8,630(108)	92	112	5,464(109)	62	117	2(R)	R
678	TNG6^4/7Tetep	8,407(106)	91	106	5,098(101)	61	108	3(MR)	MR
696	TNG67^4/Dawn	7,981(100)	92	114	5,332(106)	61	115	2(R)	R
711	TNG67^4/Carreon	8,222(103)	93	114	6,245(124)	64	119	3(R)	MR
726	TNG67^4/Tetep	8,130(102)	93	109	5,348(106)	64	114	1(R)	R
CK	TNG67	7,963(100)	92	106	5,029(100)	63	115	S	S

a: Days from transplanting to heading.

From our efforts shown above, more *japonica* strains and lines having the BL resistance from *indica* varieties will come up for yield trials. Introduction of blast resistance genes into *japonica* varieties has also been the approach of Japanese researchers in this line in recent years. Gene *Pi-k* from Litchi-hung to Kanto 51, another *Pi-k* to Kusabue, *Pi-ta* from Tadukan, *Pi-z* from Zenith, *Pi-z*^{t} from TKM-1 and *Pi-b* from Tjina etc. to japanese varieties (28), all are the examples. Many of these newly bred resistance varieties of *japonica* have been also used in our breeding program. In some case, they eventually introduced the same resistance gene from different donor parents (28). Our principle approach is to introduce the resistance gene from *indica* into Tainung 67 and to accumulate them. We may waste our efforts in introducing the same gene from different donors in some cases, however, we should be able to introduce different resistance genes from *indica* varieties into *japonica* as japanese did.

2. Breeding for resistances to yellow dwarf and other diseases

In the past

Yellow dwarf disease, although not a major disease of rice in Taiwan, occurs in the second crop with the increasing importance (7, 22). The disease damage is particularly serious in the ratoon cultured rice, which is considered one of the approaches to further reduce the cost of production in rice. Yellow dwarf disease, incited by a mycoplasma, can be easily controlled by the application of insecticides at seedling stages of

the second crop rice, since it is transmitted by the vector insects, *Nephotetix* leafhoppers. Of course, use of the resistance is the cheapest method of disease control without any adverse side-effects resulting from the application of agricultural chemicals.

Chen *et al.* (7) detected three varieties, namely Firooz, Kabara and C4-63 to be highly resistant to yellow dwarf disease among greenhouse and field-tested 1,430 rice varieties. The resistance was later found to be controlled by a single dominant gene (21). A backcross breeding program to introduce the resistance gene of Firooz and Kabara into Tainan 5 and Tainung 61 (22) resulted in the development of five yellow dwarf resistant strains of Tainung 61 genetic background, YD-15, 22, 28, 62 and 75, four being of Kabara and one being of Firooz origins (22) of the resistance. These YD strains were not released due to the rapid expansion of the rice area of high yielding Tainung 67.

Backcross breeding to Tainung 67

In the 1979 second crop, another backcross breeding program was initiated by us to introduce the yellow-dwarf resistance into Tainung 67. The outline followed in this breeding program is shown below.

1979-II……Tainung 67/Firooz, crossed.

1980-I……F_1, Tainung 67/Firooz, backcrossed to Tainung 67.

1980-II……BC_1F_1, Tainung 67^2/Firooz, 2 families, inoculated with the vector insect carried the pathogen by pathologist Dr. C. C. Chen, then screened and backcrossed again by us.

1981-I, II…BC_2F_1, Tainung 67^3/Firooz, 12 families, inoculated and screened as in the BC_1F_1.

1982-I……BC_2F_2, 38 populations, screened in the field.

1982-II……BC_2F_3, 22 lines, screened in the field.

1983-1……11 strains in the preliminary yield trial (PYT).

Table 6. Agronomic performance of yellow-dwarf resistant strains (TNG67^3/Firooz) in replicated yield trials (1983).

Strain No.	1st crop				2nd crop				Lodging index, 2nd crop	LBL	BLB
	DFTH[a]	Pl. hgt. (cm)	Yield kg/ha	Yield (%)	DFTH[a]	Pl. hgt. (cm)	Yield kg/ha	Yield (%)			
TNGY 3	93	113	6,815	(86)	……… Discard				—	4—5	—
TNGY 13	89	116	7,075	(89)					—	4—6	—
TNGY 18	89	108	7,704	(97)					—	4	—
TNGY 19	93	109	7,870	(99)					—	3—4	—
TNGY 20	92	110	8,241	(104)	65	107	5,484	(109)	0.5	3—4	3—5
TNGY 22	91	110	8,389	(105)	64	111	5,727	(114)	0	3—4	3—5
Tainung 67 (CK)	92	106	7,963	(100)	62	115	5,029	(100)	1.25	7—9	3—5

a: Days from transplanting to heading.

1983-II……2 strains in the advanced yield trial, another 2 strains in the PYT.

1984………Thirteen TNGY strains from this breeding program will be tested for the disease resistance and yield performance.

The agronomic performances of six TNGY strains tested in replicated yield trials in 1983 are shown in Table 6. There were 2 strains, TNGY 20 and 22 outyielded Tainung 67 (Table 6). We will continue the test of these strains for grain yield and the disease resistance and cross them with the insect resistant lines.

Resistance to the bacterial leaf blight (BLB)

To the leaf blight disease Tainung 67 was commonly rated as moderately susceptible in the uniform disease nursery, while Tainan 5 was resistant. Local extension workers reported the sporadical occurrence of the disease in the second crop of Tainung 67 in recent years, although no increasing trend of the diseased area of rice has been noted. Therefore, the disease is still considered minor in Taiwan. Since no economical chemical is available for controlling this disease, we have to introduce the resistance into Tainung 67.

Four pathotypes of the leaf blight bacterium in Taiwan were identified based on five Japanese differentials (20). Tainung 67 responded to these four pathotypes in a score range of 5-7. Even though isolate No. 607 belonging to pathotypes III gave a higher disease score"7" than No. 604 belonging to pathotype II did in greenhouse (20), we found a considerably stronger pathogenicity of isolate No. 604 in the field test. Therefore, we have been using isolate No. 604 in testing our breeding materials every season for the disease resistance.

Two groups of resistance sources were used in the crossing, one was the *japonica* varieties such as Wase-aikoku, Tainan 6, Koshihikari and other japanese varieties, and another was the *indica* like TKM-6, DV85 and various IR strains. The segregating materials of various generations were inoculated by clipping method with the bacterium suspension of Academia Sinica isolate No. 604 prepared by us. The results of BLB test on yield-tested strains in the 1983 second crop are shown below.

Disease scale	2	3	4	5	6	7	8	Total strains
Advanced strains		1		36		19		56
Preliminary strains		12		85		28		127

3. Breeding for planthopper resistance

In the past

The brown planthopper (BPH) and white-backed planthopper (WBPH) have been the most destructive insects of the second crop rice in Taiwan. The total rice area infected with the insects in the island has been about 80,000-120.000 ha annually and the rice area applied with insecticides for BPH control being about 150,000-250,000 ha per year. The insects, so far, have been controlled by the chemicals that cost farmers about NT$800 million a year (1981) (24). Studies and breeding for the resistance to

brown planthoppers in the past centered mostly on *indica* varieties, of which rice quality did not meet the consumer's requirement (12). For this reason, no BPH resistant *indica* varieties that were released in the past became a major variety in Taiwan. Tainung 68 released in 1982 was the first BPH-resistant *japonica* cultivar in Taiwan. Its resistance is expressed at late growing stages (5), although no BPH resistance gene was detected by seed-box technique. Other new *japonica* strains resistant to BPH were Chianung yuh 243 that received the resistance of Mudgo, and Tainung yuh 8005 and 8849 from a wild rice, *Oryza rufipogon* (16). Although without BPH resistance gene, Tainung 67 showed a better tolerance to BPH than Tainan 5 at late growing stages of the second crop rice. This led to the reductions in the BPH infected area by 21% and in the controlled area by 23 % in the island second crops of 1977 to 1981.

Table 7. Yield performance of two BPH-resistant strains of rice in three years.

Year-season	TNGY8005	TNGY8849	Tainung 67	Site
1981—I	6,700(94)	6,800(95)	7,150(100)	TARI,
—II	5,040(122)	4,940(119)	4,140(100)	replicated plots
1982—I	5,920(100)	5,700(96)	5,951(100)	Regional tests,
—II	5,320(98)	5,050(93)	5,450(100)	7 sites
1983—I	6,960(100)	6,770(96)	6,960(100)	TARI,
—II	5,997(104)	6,240(108)	5,760(100)	large, plot
Adv.-II[a]	5,980(119)	6,170(123)	5,030(100)	Replicated plots

a: Advanced yield test.

Table 8. Reaction of BPH-resistant rice strains to different BPH biotypes with seedbox technique.

Strain No.	Reaction to biotype			BPH damage 3/		White-backed planthopper
	1 1/	2 2/	3 2/	Degree 4/	Pattern 5/	
TNGY 8005	R	R	R	2.5	I	S
TNGY 8849	R	MR	R	3.0	II	R
TNG 67	S	S	S	—	—	MR

1/ : Tested at the F_3 line, 2/ at the F_4 line.
3/ : Tested at the F_6 strain with biotype 1.
4/ : Average of damage scales in the damage progress curve.
5/ : Pattern of the progress curve; I, II=lower degrees of damages than H105 with different slopes of the curves.

BPH-resistance from a wild rice *Oryza rufipogon*

In the progenies of the F_1 between Tainung 61 semidwarf mutant and *O. rufipogon* (IRRI Acc. No. 100923) backcrossed with the mutant two or three times, BPH-resistant

Table 9. Reaction of BPH-resistant rice strains to leaf blast disease.

Year-season	TNGY 8005	TNGY 8849	Tainung 67	Site
1981—I	1.5	3	8.3	4 nurseries
—II	1	1.5	9	TARI, Chiayi
1982—II	3	2	9	TARI, Chiayi, IRRI
1983—I	1.5	1.5	9	TARI, Chiayi
—II	1.8	2.2	9(1:IRRI)	TARI, Chiayi, IRRI

lines were detected with seedbox technique (16). Tainung 61 that belongs to *japonica* is the two dose parent of Tainung 67. From the progenies of the F_1's between these BPH resistant lines and two blast resistant *japonica* strains, we selected and established new rices trains resistant to BPH and BL in the 1980 second crop (Table 8, 9). The BPH resistance gene was found to be *Bph 3* or certain unidentified gene(Table 8). The selected strains were yield-tested from 1981 continuously for three years including regional tests at 7 sites in 1982 (Table 7). TNGY 8005 yielded almost similar with Tainung 67, While TNGY8849 yielded higher than Tainung 67 by 8% to 23% (Table 7). Both TNGY8005 and 8849 were resistant to blast disease, not only in Taichung and Chiayi nurseries but also at IRRI, Philippines. The range of BL resistance is considered wide. Although TNGY8005 showed a yield potential similar to Tainung 67, it was not resistant to the white-backed planthopper (Table 8) and had the poor eating quality of rice. Therefore, we will recommend TNGY8849 for registration in 1984.

BPH resistance from cultivated rice varieties

Four BPH resistance genes have been known so far in the cultivated rice. The typical varieties for these genes are Mudgo for *Bph 1*, H105 for *bph 2*, Rathu Heenathi for *Bph 3* and Babawee for *bph 4* (26). These genes, particularly *Bph 1* and *bph 2*, have been incorporated into various IR strains, that can also be used as the source of resistance. We started to introduce these genes into Tainung 67 in 1978. TKM-6, Chianung yuh 243, IR28 and other IR varieties and strains provided the *Bph 1* gene for our breeding program. Taiunug sen 12 and Taichung sen 10 provided the *bph 2* gene, TNGY 8005, 8849 and Rathu Heenathi the *Bph 3* and Babawee the *bph 4*.

The F_1's between Tainung 67 and the resistant stocks mentioned above were backcrossed to Tainung 67. The resulted BC_1F_1's were tested by Plant Protection Department, Chiayi AES/TARI for BPH-resistance and then screened by us. In some crosses the backcrossing and screening were repeated one more time. Seedbox technique was used for testing and screening the segregating materials. In the second crop when the insect prevailed, we also used the severe occurrence of BPH in the field for screening the materials. The strains selected and established from these materials reached yield-test in 1983(Table 10). In the 1984 first crop, more new strains resistant to BPH will be entered in the preliminary yield trial. Apparently, the times of backbrossing made in this breeding program were not adequate. Therefore, the rice quality, plant

type and other agronomical traits of these strains need further improvement.

Table 10. Number of rice strains and their donor parents tested in the preliminary and advanced yield trials in the 1983 second crop.

Yield test	Blast resistance	BPH[a] resistance				BLB[b] resist.
		Bph 1	bph 2	BPh 3	bph 4	
Advanced	28	1	2	2	1	2
Preliminary	58	7	9	3	3	3
Donor parents	Tetep, Dawn TN6, M1-48 Carreon Dawn, Dular Shenso TNG62, BL2, 4, 5 Pil	TKM 6 IR 2178 CNGY 243 IR 28 IR 8073 IR 13415 IR 5533 CNGY 252	TNGS 12 TCS 10	TNGY 8005, 8849, Rathu- Heenathi	Babawee	Waseaikoku Other *Keng* var.

Yield test	Yellow dwarf resist.	Good rice quality	Aromatic rice	Semidwarf	Others	Total
Advanced	2	7	2	7	2	56
Preliminary	2	18	7	9	8	127
Donor Parents	Firooz	Hokuriku 100 Mutsunishiki Fujihikari Sasaminori Toyonishiki Ariake	Basmati	Chaoyanchao Milyang 23 TCS 3 Kwanluai	TPCZ Chyutze Silwah LM 182	43

a: Brown planthoppers. *b*: Bacterial leaf blast.

Resistance to white-backed planthoppers

The white-backed planthopper (WBPH), once a serious insect pest in Taiwan, easily becomes predominant when the host plant is resistant to BPH but not to WBPH. IRRI (18) reported four WBPH resistance genes in rice, i. e. *Wbph 1* from N22, *Wbph 2* from Chempa, *Wbph 3* from ADR52 and *Wbph 4* from Podiwi-A8. Differences in the resistance existed among varieties identified as having the same major gene *Wbph 1* or *Wbph 2* (18) assuming to be due to minor gene differences. All the resistance soruces

explored by IRRI belong to *indica.* We tested a number of *japonica* varieties and strains for WBPH resistance cooperated with Applied Zoology Department, TARI. Tainung yuh 8849 and Chianung yuh 251 were found resistant, while Tainung 67 and Taichung 184 were moderately resistant. A genetic study revealed that the WBPH resistance of Tainung 67 seemed to be controlled by a single recessive gene. An expanded genetic study and breeding for WBPH resistance are in progress.

4. Application of anther culture to varietal improvement of japonica rice

In the past

The technique of anther culture in rice has been available for about a decade in Taiwan (6), yet, its impact on rice improvement has been very much limited. Rice breeders were not familiar with, or to some extent skeptical to the feasibility of, this technique to be used in rice breeding. In addition, it takes time to improve the culture technique particularly the medium (10) and to demonstrate that the anther-derived plants were of microspore origin. Chen *et al.* (8, 9) obtained the anther-derived plants of either n or $2n$, whose marker genes assorted in an independent manner or showed a linkage relationship. The results of genic analysis on the F_2 populations showed a good agreement with those from anther-derived plants (8). The conclusion that anther-derived plants are indeed of microspore origin is supported not only by the results of genetic studies but also by the cytological observation (8). In the past 15 years, public investments on rice breeding were centered mostly on the improvement of *indica* varieties or *indica-japonica* hybrids, even though the cultivated area of this rice has been dropping at an annual rate of about 10,000 ha. Since the percentage of callus formation by *indica's* anthers is very low, it is quite disadvantageous to apply this technique to *indica* rice breeding. On the other hand, most of desirable traits such as disease and insect resistances exist in the *indica.* We have to transfer these desirable traits by backcross breeding into Ponlai rice, that presently occupies more than 90% of the total rice area in Taiwan. As reported in the previous sections, the writer has been working on this direction to transfer various desirable traits into Tainung 67. Furthermore, anther culture was used in cooperation with the tissue culture laboratory, TARI for combining these traits in the Ponlai. The preliminary results obtained in this research work are shown below.

Anther culture of the double cross F_1's

In the 1982 second rice season, the hybrid materials in our backcross breeding program for BL resistance reached the BC_4 generation. The resistant BC_4 plants selected at Kuohsin BL nursery were brought back to the institute for double-crossing. As shown in Table 11, we selected 21 crosses of them for anther culture. Since the double cross F_1's may segregate for BL resistance, we subjected these hybrids F_1 No. 1462-1511 to blast test. Department of Plant Pathology, TARI inoculated them with the spore suspension of composite blast fungus. The susceptible F_1 plants were discarded by us to leave only the resistant plants for anther culture or continuous propagation and selection. According to the data obtained by the tissue culture laboratory, a total of 63,251 anthers from the F_1's of 21 crosses were cultured. The percentages of callus-

formed anthers ranged from 69.2% to 2.8% with an average of 30.5%. The total number of calluses that produced green plants was 1,596 (Table 11). In other words, only 8.1% of the calluses produced green plants, or 2.5% of the cultured anthers produced green plants. These percentages are considered low. Therefore, efforts are

Table 11. The AC$_1$ plants and AC$_1$S$_1$ lines of rice derived from anther culture of the double cross F$_1$'s (1983 first and second crops).

F$_1$ NO.	Cross	AC$_1$ plants from test-tube	AC$_1$ plants in field				AC$_1$S$_1$ lines	
			Total	n	$2n$	Others	Grown	Select.
1462	TNG67^5/Dawn//TNG67^5/Carreon	10	3	2	1	0	1	1
1463	TNG67^5/Dawn//TNG67^5/Tetep	75	34	17	17	0	16	3
1472	TNG67^5/Tetep//TNG67^4/Dular	35	12	11	1	0	2	0
1473	TNG67^5/Tetep//TNG67^5/Carreon	133	48	23	25	0	24	9
1474	TNG67^5/Tetep//TNG67^5/Dawn	25	7	2	5	0	5	1
1478	TNG67^4/Dular//TNG67^5/Carreon	45	7	6	1	0	1	0
1481	F$_2$(TNG67^4/Dawn)//F$_2$(TNG67^4/Tetep)	99	30	25	5	0	5	2
1484	F$_2$(TNG67^3/Dular)//F$_2$(TNG67^3/Dawn)	118	28	18	10	0	9	1
1486	F$_2$(TNG67^4/Tetep)//TNG67^4/Dawn	331	187	126	56	5	59	14
1492	TNGY6043^b//TNG67^5/Tetep	5	1	1	0	0	0	0
1499	TNGY8023//TNG67^5/Tetep	39	8	5	2	1	3	1
1501	TNGY8023//TNG67^4/Tetep	26	6	1	5	0	4	1
1504	TNGY8814//F$_2$(TNG67^4/Tetep)	0	0	0	0	0	0	0
1505	TNGY8814//F$_2$(TNG67^4/Dular)	15	9	6	2	1	2	0
1507	TNGY8849//F$_2$(TNG67^4/Dawn)	99	20	15	5	0	7	2
1508	TNGY8849//F$_2$(TNG67^4/Dular)	66	25	16	9	0	9	5
1509	TNGY8933//TNG67^5/Tetep	40	14	9	5	0	5	1
1511	TNGY8933//F$_2$(TNG67^4/Dawn)	95	27	12	14	1	15	4
JF$_1$—15	TNGY6043/CNY252^a	12	2	1	1	0	1	0
JF$_1$—16	TNGY8005/CNY252	0	0	0	0	0	0	0
JF$_1$—17	TNGY8023/CNY252	0	0	0	0	0	0	0
JF$_1$—18	TNGY8814/CNY252	78	30	22	8	0	11	2
JF$_1$—19	TNGY8849/CNY252	0	0	0	0	0	0	0
JF$_1$—20	TNGY8933/CNY252	116	48	17	29	2	34	7
JF$_1$—21	TNGY9198/CNY252	105	35	18	17	0	17	7
Total		1,567	581	353	218	10	230	61

a: Having *Bph 1*, blast and bacterial leaf blight resistances.
b: TNGY6043-9198, having *Bph 3* or other unidentified gene and blast resistance.

being made to improve these percentages by the tissue culture laboratory.

Among 1,567 green plants that were transferred from test-tubes to soil in pot, only 581 plants, or 37.1% survived in the paddy field (Table 11). The loss of green plants occurred at the stage immediately after the transfer of seedlings from test-tubes to soil. This percentage was greatly improved later by shortening the time period of seedlings in test-tubes or to transplant the young seedlings to sterilized soil and by giving the seedlings enough temperature and air moisture after the transfer. The breeder started to take care of these new plants that were finally transplanted to the paddy field. A bunch of seedlings from a cullus constitutes a hill in the field. Among 581 AC_1 plants, 353 or 60.8% showed a morphological feature characteristic of haploid, 218 or 37.5% were normal diploid and 10 or 1.7% were tetraploid or others(Table 11). We selected mostlly the diploid plants, that exhibited uniform characteristics within plants. A few plants had tillers showing distinctly different traits such as plant height or grain shape, indicating that different genotypes existed within plants althongh in a very low frequency. Panicle selection was practiced on this type of plants, if they looked desirable.

Serious panicle blast happened to occur on these AC_1 plants in the 1983 first crop, particularly on the susceptible haploid plants. All panicles of such haploid plants developed typical but serious blasting that had never been observed in the ordinary diploid plants. It seems that the haploid plants having only one set of chromosomes are particularly apt to diseases and insects, if they are susceptible. We may double the chromosome number at the adult stage of AC_1 plants or at the callus stage by colchicine treatment. The percentage of diploid plants may be raised by treating the calluses with a certain concentration of colchicine that acts most on haploid but less on diploid cells. For the present, we have to double the chromosomes at seedling stage after the seedlings are identified to be haploid. It was rather easy to identify the haploid seedlings by observing the sizes of epidermal cells including stomatal cells of leaves with SUMP or printing method. However, to treat the growing points of a large number of seedlings with colchicine is not an easy task. We moved about 20 haploid plants that were resistant to panicle blast into green house for ratoon culture. So far no any seed has been obtained from these stubbles. Therefore, the only way we can do with these AC_1 plants at present is to select normal and desirable plants, all being diploid, and to discard haploid, tetraploid and other undesirable plants.

Testing and selection of the AC_1S_1 lines

A total of 230 plants or panicles were selected from the AC_1's of the 21 crosses for progeny-testing (Table 11). The progenies of these plants will be thus $AC_1 S_1$. We planted each of these AC_1S_1 lines in a paddy field for observing their performances and also tested for their resistances to the blast, bacterial leaf blight, brown planthopper and white-backed planthopper. As usual, upland BL nursery with corn border lines was used for BL test, and No. 604 strain of BLB bacterium was inoculated by us with clipping method for BLB test. Chiayi AES and Department of Applied Zoology, TARI respectively tested for BPH and WBPH resistances.

In general, these AC_1S_1 lines showed an acceptable degree of uniformity except a small number of lines. Those lines related with TNGY and CNY parents (Table 11) were mostly poor in plant-type, although many of them were resistant to both BL and BPH. Severe planthoppers including BPH and WBPH that frequently attacked the second rice crop brought down the yield per unit area of these lines. The yield of a line was estimated from 45 single-spaced plants. Their yields varied from 2 t/ha to 5.5 t/ha with 5 t/ha of the contol's yield. We bulked seed of 5 or 6 plants fom each of the selected lines to establish a strain for a preliminary yield test, and finally 61 strains were selected (Table 11).

Segregations of leaf blast resistance and nonshattering habit of grains among the AC_1S_1 lines.

The segregation of leaf blast resistance among the AC_1S_1 lines obtained from the F_1's of 7 crosses is shown in Table 12. Although the number of lines per cross in some crosses was small, the segregation of BL resistance apparently occurred among the AC_1S_1 lines derived from the F_1's between resistant parents. In some crosses, the segregation pattern could be explained based on the assumption of 3 or 4 pairs of genes that the parents differed (Table 12). Hence, there will be no problem to accumulate the resistance genes from different sources as we intent. However, how to identify the

Table 12. Segregation of leaf blast resistance among the AC_1S_1 diploid lines of rice derived from anther culture (upland BL nursery with corn border lines, 1983 second crop).

F_1 No.	Cross	1[a]	2	3	4	5	6	7	8	9	Total lines	Possible ratio $p(X^2)>5\%$
JF_1—18	TNGY8814/CNY252	7				2					9	1 : 1, 3 : 1
JF_1—20	TNGY8933/CNY252	21				4		1			26	3 : 1, 7 : 1
JF_1—21	TNGY9198/CNY252	9		5				1			15	7 : 1,15 : 1,31 : 1
F_1 1508	TNGY8849⫽F_2 ($TNG67^4$/Dular)	8		1							9	?
F_1 1511	TNGY8933⫽F_2 ($TNG67^4$/Dawn)	10								3	13	1 : 1, 3 : 1 7 : 1, 15 : 1
F_1 1486	F_2($TNG67^4$/Tetep) ⫽$TNG67^4$/Dawn	43		5		3		2		2	55	7 : 1
F_1 1473	$TNG67^5$/Tetep⫽ $TNG67^5$/Carreon	9		2				4			15	1 : 1,3 : 1,7 : 1

a: BL disease degree, 1=highly resistant.

Table 13. Segregation of nonshattering (NS) and shattering (S) habits of grains among the AC_1S_1 diploid lines of rice derived from anther culture.

F_1 No.	Cross	NS	S	Total lines	$(1:1)\chi^2$
JF_1—18	TNGY8814/CNY252[a]	6	3	9	1.0^{ns}
JF_1—20	TNGY8933/CNY252	17	9	26	2.46^{ns}
JF_1—21	TNGY9198/CNY252	5	12	17	2.88^{ns}

a: Possessing nonshattering habit of grains.

Table 14. Segregation of brown planthopper resistance among the AC_1S_1 diploid lines of rice derived from anther culture.

F_1 No.	Cross	0.75*a*	2.25	3.75	5.25	6.75	8.25	Total lines	Possible ratio $p(X^2) > 5\%$
JF_1—18	TNGY8814/CNY252	3	1		1	1	3	9	1 : 1
JF_1—20	TNGY8933/CNY252	5	3	4	1		14	27	1 : 1
JF_1—21	TNGY9198/CNY252	7	1	3	1		3	15	1 : 1, 3 : 1
F_1 1508	TNGY8849/F_2 (TNG67^4/Dular)	4					5	9	1 : 1
F_1 1511	TNGY8933/F_2 (TNG67^4/Dawn)	3			1	4	6	14	-

a: Average of BPH damage degrees, 1=highly resistant.

Table 15. Segregation of white-backed planthopper resistance among the AC_1S_1 diploid lines of rice derived from anther culture.

F_1 No.	Cross	R	S	Total lines
1486	F_2(TNG67^4/Tetep)/TNG67^4/Dawn	1	57	58
1505	TNGY8814/TNG67^4/Dular	1	1	2
1508	TNGY8849/F_2 (TNG67^4/Dular)	4	5	9
1511	TNGY8933/F_2 (TNG67^4/Dawn)	3	11	14

genotype possessing a large number of resistance genes will be the next job for us to do. The genotypes having one and three or more resistance genes will show the same degree of resistance to a given range of pathogen. IRRI has been subjecting their rice materials to a wide range of blast fungus in the IRBN in order to identify the genotypes having a wide range of resistance. We may expand our range of BL nurseries to IRRI, Philippines or Japan for this purpose, although this range is still considered narrow. Or, we may test-cross the resistant AC_1S_1 lines to Tainung 67 and examine the segregation pattern of the test-cross F_2.

One parent, CNY252, happened to have the nonshattering habit of grains that could be used as the gene marker. In the crosses related with CNY252, the shattering and nonshattering lines of AC_1S_1 segregated in a ratio of 1:1 (Table 13). The shattering gene, *sh*, is located on the Takahashi and Kinoshita's linkage group 8 with many BL-resistance genes such as *Pi-a*, *Pi-5*, *Pi-k*, *Pi-m*, *Pi-4*, and *Pi-7* (23). A very close linkage is noted between *sh* and *Pi-a* genes (23). The ratio of shattering to nonshattering AC_1S_1 lines in the BL-resistance category deviated greatly from 1:1 probably due to the linkage between the two traits except in the cross of JF_1-18. JF_1-18 apparently did not have enough number of AC_1S_1 lines (Table 13). Since the nonshattering habit of grains is not desirable in Taiwan, it is better to avoid using CNY252 as the source of BL resistance.

Segregation of BPH and WBPH resistances among the AC_1S_1 lines

Table 14 shows the segreghtion patterns of BPH resistance in the AC_1S_1's of 5 crosses. The results seemed to deviate from what we had in mind. TNGY and CNY strains, both resistant to BPH, are supposed to possess different *Bph 3* and *Bph 1* genes, respectively; and the two genes are independent one another. The segregation patterns in Table 14 show as they possess the same resistance gene except JF_1-21 and F_1 1511. We still do'nt know the reason why the results did not come out as we expected.

Segregations of WBPH in the AC_1S_1's of 4 crosses are shown in Table 15. Among those parents used in crossing, only TNGY8849 is resistant to WBPH. The AC_1S_1 lines of F_1 1508 that was related with TNGY 8849 segregated for the WBPH susceptible and resistant in a ratio of 1:1 (Table 15). A very low frequency of resistant lines that appeared in other crosses probably had their origin of resistance from Tainung 67. Even though Tainung 67 was rated moderately resistant to WBPH in our early test, many AC_1S_1 lines that received 4 doses of Tainung 67 did not show any resistance (Table 15). There apparently remain still many questions to be answered about the BPH and WBPH resistances in these anther-derived AC_1S_1 lines.

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稉稻抗病蟲育種[1]

黃眞生[2]

摘要

爲改良臺農67號之稻熱病抵抗性，將臺農67號 Tetep, Carreon, Dawn 等捐與品種雜交，然後回交於臺農67號3至4次。其 BC_1F_1 之遺傳研究顯示，對四個稻熱病病菌生理小種，Tetep 是最富有抗病基因之種源。另創設玉米保護行稻熱病病圃，以便迅速篩選育種系統。由此育種計畫選得多數品系，均具有稻熱病抵抗性，且比臺農67號高產。我們同時將臺農67號與抗黃萎病的 Firooz 雜交，後回交臺農67號2次。由回交分離後代選出11品系乃抗黃萎病者，其中有二品系比臺農67號高產。經過2次的育種計畫，將野生稻 *Oryza rufipogon* 褐飛蝨抵抗性轉移至蓬萊稻，最後選出抗稻飛蝨及稻熱病的 TNGY 8849 將提出命名登記。臺農 67 號也同樣與具 *Bph 1, bph 2, Bph 3* 及 *bph 4* 的種源雜交，後回交臺農67號2次。由此選出之品系正在參試於產量比較試驗。另經測驗明瞭有數個稉稻品種對白背飛蝨有抵抗性，有關此蟲抵抗性的遺傳育種試驗正在進行中。另與組織培養室合作，做21個雙交 F_1 之花藥培養，是上述回交育種育成系統或品系間的雙交。從1,567個綠色的 AC_1 營養系，得到230雙倍體 AC_1S_1 系統以供篩選之用。此雙倍體之出現比率後來得大幅提高。由稻熱病，稻飛蝨抵抗性以及脫粒性等在 AC_1S_1 之分離形式而言，雙交及花藥培養的運用使不同優良性狀合併於同一品種應該是可行而能迅速完成。

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花藥培養於水稻育種之應用[1]

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摘要　稉稻花藥培養育成品系與系譜法育成品系，雖各來自不同的雜交親本，在第一期作有相似的產量表現，但於第二期作花藥培養品系却顯著的低產。其原因是這些品系之結實率及穗重偏低，且由選拔累積優良基因型之機會少，以致高產品系顯著的減少。單交、複交及回交雜種的花藥培養系統之選拔結果顯示，單交材料似較適合於應用花藥培養的育種。因其遺傳背景比較單純，目標性狀如稻熱病、褐飛蝨抵抗性等均以正常的方式分離，而重組也無問題之故。

水稻花藥培養始於日本(12)，至今已有17年之歷史，其間國內外有許多的研究報告(1,2,4,5,6,7,8,9,10,12,14)而今應用於育種且有顯著效果者，極爲有限(4,5,9)。雖然以花藥培養育成的水稻新品種爲數並不少(4,5)，但受當地農民廣汎採用的品種却幾乎等於零。可能原因之一是花藥培養常止於組織培養家。除非組織培養家與育種家有密切的合作，或者任何一方能兼代另一方的作用，否則難有良好的成果。因花藥培養引發各種突變(2,9,10,11)，育成品系軟弱又低產(11)，以致不少育種家多少懷疑花藥培養在育種的可用性。在水稻方面，也有人報告部分花藥培養品系結實率低而低產(14)。近年來日本有34%之試驗場已開始水稻此方向的合作(3)，有的試驗場每年育成約數百個花藥培養系統，主要目標是合併抗稻熱病及耐寒性，有些品系已進入推廣前之調查(5)。本所於民國63年正式開始花藥培養之試驗研究(1)，民國70年與育種家合作。最初使用材料均爲秈稉雜交 F_1，最近才改用稉稻品種間雜種。稉稻有花藥癒傷組織形成率高之優點(5,6,8)，應該受重視。

材料及方法

本試驗使用之材料有兩類，一類是系譜法及花藥培養法育成之水稻新品系，第一期作各有62及61個，第二期作各有38及18個（表１）；另一類是民國72年花藥培養用之雜種材料，包括單交６組合，雙交15個組合及回交材料12組合的 AC_1S_0 個體及其 AC_1S_1 系統（表５）。

第一類是於本所水稻抗病抗蟲育種計畫中以系譜法育成之材料，係民國72年第二期作成立之品系，共62個，於翌年第一期作參加產量比較試驗。第二期作經淘汰及晉升後剩餘25個品系，加入由同類材料繼續選出之品系13個，共38個品系供試。以花藥培養育成之 AC_1S_2 品系61個，同樣是於民國72年第二期作成立爲品系；於下（73）年第一期作與系譜法育成之62品系一起參加產量比較試驗，第二期

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作經淘汰後剩18個AC_1S_3品系（表 1 ）與系譜法育成者38 品系一起參試。產量比較試驗的設計乃沿用本所初級產量比較試驗之慣用法，二重複，每小區60欉，行株距爲28×16公分。調查項目是小區稻穀產量，產量構成因素，抽穗期、株高、倒伏性等。

表1. 於產量試驗供試之花葯培養及系譜法育成水稻品系的數目及雜交親本（民國73年）

Table 1. Cross parents and the numbers of pedigree and anther culture derived stains of rice in yield trial (1984).

系譜法育成 Pedigree Strain			花葯培養育成 $AC_1S_{2,3}$ strains		
雜交親本 Cross parent	品系數 Strain No. I	品系數 Strain No. II[1]	雜交親本 Cross parent	品系數 Strain No. I	品系數 Strain No. II
$TNG67^3$/Rath Heenati	1	1	$TNG67^5$/Dawn//$TNG67^5$/Carreon	1	
$TNG67^2$/Babawee	1	1	$TNG67^5$/Dawn//$TNG67^5$/Tetep	3	1
$TNG67^{2\ or\ 3}$/TNS12	3	1	$TNG67^5$/Tetep//$TNG67^5$/Carreon	9	2
$TNG67^{1\ or\ 2}$/IR lines & other indica	17	9	$TNG67^5$/Tetep//$TNG67^5$/Dawn	1	
$TNG67^4$/Mudgo	3		F_2($TNG67^4$/Dawn)F_2//($TNG67^4$/Tetep)	2	1
F_2($TNG67^2$/TCS10)//TNG67	5	2	F_2($TNG67^3$/Dular)//F_2($TNG67^3$/Dawn)	1	
$TNG67^2$/$BL_{2:5}$ & a japonica	4	1	F_2($TNG67^4$/Tetep)//$TNG67^4$/Dawn	14	6
TNGY8023//$TNG67^5$/Dular	1	1	TNGY8023//$TNG67^5$/Dular	1	1
TNGY8023//$TNG67^5$/Dular	2		TNGY8023//F_2($TNG67^4$/Tetep)	1	1
TNGY8849//F_2($TNG67^4$/Dawn)	2	2	TNGY8849//F_2($TNG67^4$/Dawn)	2	
$TNG67^{3,4,5}$/Tetep, Dular, Dawn	17	6	TNGY8849//F_2($TNG67^4$/Dular)	5	2
TNGY9198/CNY252	1		TNGY8933//$TNG67^5$/Tetep	1	
TNGY8849//F_2($TNG67^4$/Dawn)	2		TNGY8933//F_2($TNG67^4$/Dawn)	4	
TNGY8849 sel.	2		TNGY8814/CNY252	2	1
TNG67 (CK)	1	1	TNGY8933/CNY252	7	1
			TNGY9198/CNY252	7	2
計 Total	62	25+13[2]	計 Total	61	81

1. I, II爲第一、二期作，The 1st and 2nd crops.
2. 新加入品系，其親本與其他品系同類，則選拔世代較晚而已。

The number of newly entered strains that were selected in the later generation.

Note: TNGY=Tainung yuh, TNS=Tainung sen, CNY=Chianung yuh, TCS=Taichung sen.

第二類材料是抗病抗蟲育種計畫的新雜交組合共33個；包括單交、雙交及回交等三種材料(表 5)，以便觀察何種材料比較適合於花藥培養之育種。組織培養家負責的工作是採取F_1幼穗，雜種花藥之培養[8]，花粉植物之誘導，小植株之培養及將幼苗植至本田 。其餘工作均由育種家負責。 本期作培養107,743個花藥[1]，共得3,364綠色成株。由此選出結實的AC_1S_0個體共1,361株，於下期作做後裔檢驗，共得1,361AC_1S_1系統。有些系統接受抗稻熱病及抗褐飛蝨之檢驗，最後選出整齊的105 個系統，成立爲品系。另做單株選拔後繼續行系統繁殖者有214系統（表 5 ）。

結果與討論

花藥培養育成品系與系譜法育成品系在第一期作之產量比較：

以花藥培養育成的 61 品系與系譜法育成者 62 品系共 123 個於民國 73 年第一期作併同測驗產量(表 1)。本期作比較特殊的氣候是生育初期連續低溫，後有葉及穗稻熱病發生。一般而言，這是一個順利而豐收的期作。變量分析結果顯示花藥培養品系間的產量差異極顯著，系譜法育成者亦同(表 2)，但兩法育成品系間卻無顯著的產量差異（表 2）。此結論亦可由圖 1 而得佐證。這些品系除了育成來源不一樣外，均根據同樣的農藝性狀調查及抗病抗蟲測驗之結果而選出者。結果兩羣各60多品系的產量幾乎以同樣的方式分佈（圖 1）。取123個品系內最高產者11個及對照種臺農67號，以Duncan氏之多變域測驗求品系間平均產量差異之顯著性。結果11品系間的產量差異均不顯著，但各與臺農67號有顯著之產量差異（表 3）。11個最高產品系中只有 4 品系是來自花藥培養，其餘 7 個均爲系譜法育成者，而最高產的四個品系均爲系譜法育成者（表 3）。本試驗每重複均有 123品系（種）之多，以致重複間產量差異極顯著。重複與品系之交感自然反應到試驗機差。以上花藥培養育成品系與系譜法育成品系的雜交親本雖不同，而後者品系在第一期作似有較多的高產品系，但兩者並無顯著的產量差異。

兩種育種法育成品系在第二期作之產量比較：

第二期作供試的花藥培養育成品系有18個，是一期作篩選後留下來之精英。系譜法參試品系共有38個，乃於一期作62品系中最高產 5 個晉昇高級試驗後，剩餘57品系中選出較優者25品系，再加入新成立13個品系而成。這些新加入品系均來自同類之雜交組合，只是成立品系世代較晚而已。是故，花藥培養品系應該處於比較有利之地位。本期作氣象是標準的二期作低產天候，即生育初期高溫，後期低溫；但據糧食局報告，此仍是一個創記錄的豐收年。第二期作不論是花藥培養品系間或系譜法品系間均有極顯著的產量差異（表 2）。但兩育種法育成的品系間也有極顯著的產量差異（表 2），而花藥培養品系比系譜法品系顯著的低產。圖 1 也顯示兩類品系的產量有顯著不同的分佈型式。本試驗最高產11品系的產量，一方面與臺農67號有顯著之差異外，另一方面互相之間也有顯著之差異（表 2）。這些品系中，有四個是來自花藥培養，而剩餘 7 個乃來自系譜法，與第一期作之結果完全相同。總

表2. 花葯培養及系譜法育成水稻品系產量之變量分析

Table 2. Analysis of variance for grain yield of rice strains developed by anther culture and pedigree method.

變因 Source of variation	一期作 1st crop 自由度 Degree of freedom	一期作 1st crop 均方 Mean square	二期作 2nd crop 自由度 Degree of freedom	二期作 2nd crop 均方 Mean square
重複 Replication	1	199,699**	1	60
品系 Strain.	122	185,286**	55	45,745**
系譜法品系 (P)[1]	61	194,671**	37	46,650**
AC品系 (AC)[2]	60	177,855**	17	37,390**
P對AC	1	58,683	1	154,274**
機差 Error	122	21,167	55	11,253
計 Total	245		111	

1. Among the strains developed by pedigree method.
2. Among the strains by an her culture.

而言之，第二期作花藥培養品系內的高產品系之出現頻度，顯著的比系譜法育成品系少（圖1）。若第二期作供試之系譜法品系包括晉升高級試驗的5個品系（表3），則兩育種法高產品系頻度之差距會更大。這5個品系中的二個在高級試驗亦顯示最高產。故花藥培養品系於第二期作少有高產品系是相當有根據之結論。另一方面，花藥培養最高產品系雖比系譜法最高產品系稍為低產，但統計上並不顯著（表3），亦即兩者有相似的稻穀產量。可見兩種育種法均有同程度高產品系之出現，只是花藥培養的高產品系之頻度較低而已。

表3. 產量試驗最高產12水稻品系之育成來源及平均產量之比較（MRT, P=0.05, 2,000g/小區=7.44t/ha, 1984, TARI).

Table 3. Mean yield comparison of twelve top-yielding strains of rice and their breeding methods (2,000g/plot=7.44 t/ha).

一期作 1st crop		二期作 2nd crop	
品系代號 Strain No.	小區產量 (g/60 hills) Plot yield	品系代號 Strain No.	小區產量 (g/60 hills) Plot yield
3840* (P)[1]	2,069 a	4776 (P)	1,985 a
3583* (P)	2,027 a	4067 (P)	1,933 ab
4215* (P)	2,022 a	4939 (P)	1,899 abc
3839* (P)	1,995 a	3556 (P)	1,876 abc
4435 (A)[2]	1,973 a	3571 (P)	1,868 abc
4393* (A)	1,967 a	4510 (A)	1,850 abc
3612 (P)	1,926 a	3799 (P)	1,840 abc
4471 (A)	1,922 a	4211 (P)	1,830 abc
4476 (A)	1,919 a	4340 (A)	1,794 abc
4191 (P)	1,910 a	4362 (A)	1,766 abc
4728 (P)	1,890 a	4438 (A)	1,726 bc
TNG67 (CK)	1,565 b	TNG67 (CK)	1,657 c

*Ⅱ期作移高級試驗。Entered to the advanced trial in the second crop.

1.系譜法育成。Developed by the pedigree method.

2.花葯培養育成。Developed by anther culture.

花藥培養品系第二期作較低產之原因：

為明瞭第二期作花藥培養品系較系譜法品系低產是由那一產量構成因素所引起，特做本試驗的產量構成因素之變量分析。每品系每重複取樣三欉、二重複，共六欉合併為估計機差之用。變量分析之結果示如表4。不論是系譜法品系間或花藥培養品系間，五個性狀均有極顯著之差異存在。系譜法品系與花藥培養品系間有顯著差異之性狀是穗數、結實率及穗重。按系譜法品系的穗數是比花藥培養品系顯著的少，無法說明系譜法品系的高產。但系譜法品系之結實率及穗重則比花藥培養品系顯著的高或重。故前述系譜法產量較高乃由於結實率及穗重較高之緣故，亦即花藥培養品系低產是由於結實率低，穗重輕之關係。純系品種臺農67號經花藥培養後，部分AC_1S_1系統的產量因系統內個體的結實率分離及降低而穗重減輕，因而引起低產[2]。本試驗材料是AC_1S_3世代，上述結實率之分離及降低很可能還繼續存在，引起花藥培養品系之低產。花藥培養品系的結實率在第二期作容易降低，但第一期作却無此現象。第一期作產量構成因素的變量分析結果顯示系譜法品系與花藥培養品系的結實率並無顯

著的差異存在。為何花藥培養品系對第二期作的環境特別敏感，因而引起結實率之降低；這是值得探討的，也為育種家所應該重視的問題。水稻染色體的微小構造變異容易引起不稳性，或花粉植物的細胞質只來自花粉，本項結實率降低是否與此有關，猶待進一步的探討。

花藥培養品系在第二期作顯示比較低產的另一個可能原因是高度的同型結合率。一般作物商業品種多少具有小幅度的異型結合率，即有一、二對微效基因的異型結合。有的育種家甚是重視此種異型結合，因為它可能對不同環境有相當大的緩衝作用。花藥培養品系可能少有這種環境緩衝性質，以致二期作的結實率降低，因而低產。這看法尚待進一步的探討。

系譜法品系在第二期作較高產之原因：

前述系譜法品系是在分離世代經過幾次的人工選拔而存留下來的；篩選標準有各種農藝性狀、抗病抗蟲等，當然累積有較多的優良基因型包括褐飛蝨抵抗性，因而比花藥培養品系有較多的高產品系。第二期作38個系譜法品系中產量超過6.6t/ha以上的品系，其親本來源列如下示。

(1) TNG67^{2,3,4}/TNS12, Dular, TCS10, Dawn, Tetep, Suewon 287

(2) TNGY8023//TNG67^{5}/Dawn, Dular TNGY8933//F_2(TNG67^{4}/Dawn, Dula)
TNGY8933//TNG67^{5}/Dawn

另一方面花藥培養品系大多數來自比較單純的雜交組合，且具有臺農 67號遺傳背景者，諸如 TNGY 8933/CNY252或TNG67^{5}/Dawn//TNG67^{5}/Tetep或 F_2(TNG67^{4}/Tetep)//TNG67^{4}/Dawn等。是故花藥培養品系的產量潛力當然脫不出臺農67號之範圍。

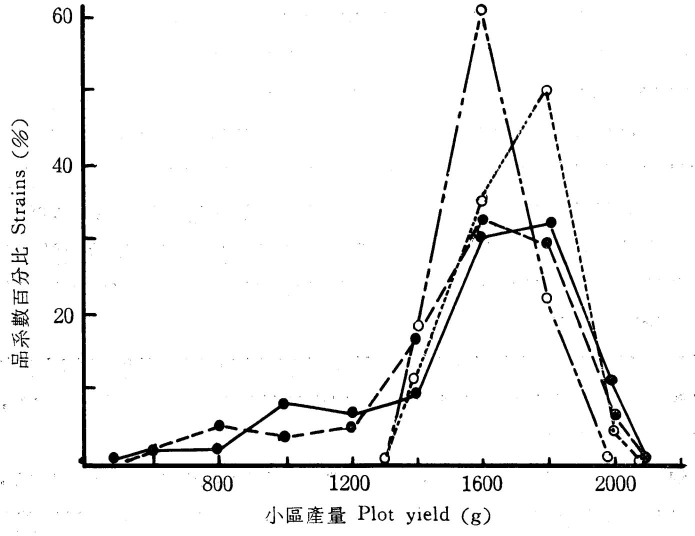

圖1. 花葯培養（虛線）及系譜法（實線）育成水稻品系於一期作（黑點）及二期作（空圈）之產量分佈 (2,000g/plot=7.44t/ha)

Fig. 1. Distribution of grain yields of anther culture (broken line) and pedigree derived strains of rice in the first (close circle) and the second crops (2,000g/plot=7.44t/ha).

半矮型秈稻品種有較高的產量潛力是國際公認之事。為提高稉稻的產量潛力，以半矮型秈稻品種為一雜交親本，再回交於當地高產稉稻品種二、三次，這是常用的育種辦法。韓國的秈稉雜交種「統一」系品種是一例。本試驗第二期作品系顯示高產者大多數來自此類之雜交組合。這是本項育種試驗的一構想，結果顯示這構想並沒錯。然而以此方式育成之高產品系通常有米質、耐寒性及穩定性較差之缺點，雖可用為橋樑品種，也無法立刻應用於一般商業性之栽培，是故猶待進一步之改良。

表4. 水稻花葯培養及系譜法育成品系二期作產量比較試驗的產量構成因素之變量分析（民國73年二期作）
Table 4. Analysis of variance for yield components of the yield trialed rice strains developed by antherculture (AC) and pedigree method (P) (1985, second crop).

變因 Source of variation	自由度 Degree of freedom	均方 Mean square				
		穗數 Panicle No.	一穗粒數 Spikelet No.	千粒重 1,000 Grain wgt.	結實率 Seedset (%)	穗重 Panicle wgt.
品系 strains	55	29.11**	1,915.94**	18.82**	357.59**	0.445**
系譜法品系 (P)¹	37	20.53**	1,431.59**	16.27**	268.33**	0.429**
AC品系 (AC)²	17	44.17**	3,082.79**	25.47**	535.46**	0.455**
P—AC	7	90.64**	$0.28^{n.s.}$	$0.09^{n.s.}$	635.48**	0.867**
機差 Error	280	6.01	166.34	1.31	63.91	0.091
計 Total	335					

1. Among the strains developed by pedigree method.
2. Among the strains developed by anther culture.

不同育種材料之花藥培養效果：

本報告第二類材料包括單交F_1 6組合，雙交$F_1$15組合及回交$BC_3F_1$12組合（表5）；其培養107,743個花藥，癒傷組織平均形成率爲 21.5%；由此得綠苗4,517株，佔培養花藥總數之 4.2%[1]；最後於本田得AC_1S_0成株3,364株[1]。這比例與日本北海道的成績[5]相比則稍差，但相當靠近。

3,364成株經過詳細的觀察後，依照其外表形態分爲三類，即二倍體、單倍體及其他三類（表5。其他類包括四倍體、混倍體，擬三倍體或其他不明植株。此等 AC_1S_0。個體的抽穗期甚是不整齊，有的植株只有一穗抽出，其餘稻穗於二、三星期後才抽出等，顯示老秧之特性。少數AC_1S_0 植株的性狀不穩定，包括嵌合體變異或後生遺傳變異。故在本世代只做不良基因型，如不結實個體、不抽穗個體或異常軟弱個體之淘汰，而不做任何選拔。所得種子於下一代做後裔檢驗共繁殖1,361 AC_1S_1系統（表5），每系統45株。有的系統種子量不足，尤其是擬四倍體爲甚。擬四倍體系統共有57系統，於另外一區集中繁殖、檢驗及選拔。

AC_1S_1 每系統除了種子量不足者外，均接受抗稻熱病及褐飛蝨之檢驗並經人工選拔成立爲品系共105個（表5），以便於下一代參加產量比較試驗。另由單株選拔選得214株（表5），於下一代 AC_1S_2 做後裔檢驗繼續觀察及測驗之用。

以上由單交6組合 F_1 19,408 個花藥，得二倍體 337 株，最後選得 28 品系，佔培養花藥數之 0.144%。由雙交12組合F_1花藥44,886個，得二倍體554株，當選品系38個，爲培養花藥數之 0.085%。最後由15組合雙交F_1的43,449個花藥，得442株二倍體，選得39品系，爲培養花藥數之 0.09%。一般說單交組合的 AC系統比較整齊，株型較佳，比較耐倒伏，當選品系似較有希望。雙交組合的 AC系統比較抗稻熱病，但株型軟弱，有些當選品系似是勉强。回交組合的 AC系統株型變化範圍大，有些當選品系也相當勉强。上述當選105品系的產量比較試驗將於民國 74年第一期作開始。其結果當會提供更正確的結論。目前的結果顯示使用單交材料做花藥培養似較有利。以花藥培養法在二年之內，很快的將二個或以上的目標性狀合併於同一品種，是一個難得可貴的優點。

花藥培養系統的抗病抗蟲性狀之分離及重組：

AC_1S_0 個體於第一期作本田常有嚴重的類似穗稻熱病發生，尤其是以單倍體爲甚，第二期作則全無。自從二年前開始使用稉稻雜交組合爲花藥培養材料以後每年如此。將本次材料的擬穗稻熱病調查結果，依照雜交方式及染色體倍數別分類列如表6。一般說，單倍體的擬穗稻熱病發生甚是明顯而極

表5. 水稻雜種F_1花葯培養當代及後代之繁殖及選拔（民73年一、二期作）

Table 5. Multiplication and selection of the first (AC_1S_0) and second (AC_1S_1) generations of rice cross F_1's after anther culture (1984, 1st and 2nd crops)[1].

雜種代號 Hybrid No.	雜交組合 Cross Combination	AC_1S_0 種植株數 Plants				AC_1S_1 系統數 Lines		
		2n (%)	n	其他 Others	計 Total	種植 Grown	成立品系 Strains estab.	保留系統 Lines select.
4627	TNG67/TNGY8005	77(33)	117	20	214	81	10	40
4628	TNG67/TNGY8849	29(33)	40	8	77	31	2	8
4629	TNG67/TNGY6043	10(22)	32	3	45	11	0	3
4630	TNG67/TNGY050	84(45)	83	21	188	89	5	22
4631	TNG67/TNGY069	14(30)	24	8	46	16	1	7
4632	TNG67/TNGY160	123(35)	205	25	353	132	10	30
3111	Tachumimimochi/TNG67//TNGY8814/CNY252/// TNGY8814//TNG67^4/Dular	45(35)	77	5	127	23	4	0
3117	HTW4/F_4 (TNG67^2/CNY243)//TNGY8005/CNY252/// TNGY6043/CNY252	14(61)	7	2	23	24	2	2
3119	HTW4/F_4 (TNG67^2/CNY243)//TNGY8005/CNY252/// TNGY6044//TNG67^5/Tetep	21(32)	33	6	65	21	5	3
3121	HTW4/F_4 (TNG67^2/CNY243)//TNGY8814/CNY252/// TNGY8933/CNY252	50(52)	46	1	97	50	2	2
3122	HTW4/F_4 (TNG67^2/CNY243)//TNGY8814/CNY252/// TNG67^5/Tetep//TNG67^5/Dawn	103(47)	91	25	219	107	6	8
3123	HTW4/F_4 (TNG67^2/CNY243)//TNGY8814/CNY252/// TNGY6043//TNG67^2/Tetep	20(31)	30	14	64	26	1	3
3124	HTW4/F_4 (TNG67^2/CNY243)//TNGY8814/CNY252/// TNGY8023//F_2 (TNG67^4/Tetep)	18(30)	34	8	60	18	1	0
3129	HTW4/TNG67^2//TNGY8814/CNY252///TNGY6043// TNG67^5/Tetep	14(33)	23	5	42	17	3	5
3136	TNGY6043//TNG67^5/Tetep///TNGY8005/CNY252	7(17)	34		41	7	1	2
3137	TNGY6043//TNG67^5/Tetep///HTW4/F_4 (TNG67^2/ CNY243)//TNGY8814/CNY252	14(38)	13	10	37	15	2	2
3141	TNGY8933//F_2 (TNG67^4/Dawn///HTW4/F_4 (TNG67^2/ CNY243)//TNGY8005/CNY252	19(14)	112	7	133	20	1	4

表5.（續）
Table 5. (Cont.)

雜種代號 Hybrid No.	雜交組合 Cross Combination	AC_1S_0 種植株數 Plants: 2n (%)	n	其他 Others	計 Total	AC_1S_1 系統數 Lines: 種植 Grown.	成立品系 strains. estab.	保留系統 Lines select.
3150	TNGY8023/CNY252///TNGY8814//F_2 TNG67^4/Dular)	8(62)	4	1	13	8	1	4
3162	HTW4/F_4 (TNG67^2/CNY243)//TNGY8005/CNY252/// TNG67^5/Tetep//TNG67^5/Dawn	67(50)	64	4	135	67	5	0
3163	HTW4/F_4 (TNG67^2/CNY243)//TNGY8005/CNY252/// TNGY8023//F_2 (TNG67^4/Tetep)	24(35)	41	3	68	25	3	2
3164	HTW4/F_4 (TNG67^2/CNY243)//TNGY8814/CNY252/// TNGY8005//F_2 (TNG67^4/Tetep)	18(22)	62	2	82	19	2	0
BC3— 1	TNG67^4/IR3259—P5——160—3	82(42)	102	9	193	82	5	
BC3— 2	TNG67^4/IR3259—P5—160—3	37(59)	23	3	63	36	0	19
BC3— 3	TNG67^4/IR3259—P5—160—3	57(41)	81	2	140	55	2	
BC3— 4	TNG67^4/IR3259—8—172—5	8(40)	12		20	8	0	5
BC3— 5	TNG67^4/IR3259—8—172—5	54(37)	87	6	147	52	3	
BC3— 6	TNG67^4/IR4227—18—3—2	29(45)	31	5	65	29	3	2
BC3— 7	TNG67^4/IR4227—18—3—2	43(40)	57	7	107	33	2	
BC3— 8	IR3259—P5—160—3/TNG67^4	45(50)	41	4	90	52	5	
BC3— 9	IR3259—P5—160—3/TNG67^4	121(55)	85	16	222	126	7	36
BC3—10	IR3259—P5—160—3/TNG67^4	10(29)	22	3	35	13	1	
BC3—11	IR3259—8—172—5/TNG67^4	45(51)	28	15	88	45	9	4
BC3—12	IR4547—5—3—6/TNG67^4	23(38)	34	3	60	23	1	1
合 計		1,333(40)	1,780	251	3,364 (100%)	1,361	105	214

Note: TNGY=Tainung yuh, CNY=Chianung yuh, HTW=Hsinchu waxy.

端，即不抗病的植株幾乎全數稻穗發病，而中間型的1穗或2至半數穗發病者少（表6）。二倍體的罹病方式較有緩衝性，即全數至半數稻穗發病者少，而中間型者多（表6）。不論於單交、雙交或回交材料均有上述之趨勢。擬四倍體的株數雖不多，也無正確的染色體數鑑定結果爲準，但尙不難看出此類植株幾乎無擬穗熱病之發生（表6）。這是否顯示此類病菌侵襲寄主的能力隨寄主的染色體倍數之增加而遞減，亦即寄主對擬穗稻熱病之抵抗性隨染色體倍數之增加而增强。

表6. 水稻AC_1S_0單倍、雙倍及四倍體罹擬穗稻熱病個體數之比較（民國73年一期作，括弧內數字爲百分比）

Table 6. Number and percentage (in parenthesis) of AC_1S_0 plants of rice infected with panicle blast (PBL) like disease in different level of ploidy.

來源 Crossing	親本 Parent	n				2n				4n(?)[2]		
		0[1]	+	++	+++	0	+	++	+++	0	++	+++
單交 Single	臺農67號交抗BL, BPH父本6組合 TNG67/BL, BPH resist.	155 (31)	29 (6)	25 (5)	292 (58)	155 (46)	57 (17)	69 (21)	52 (16)	38 (95)	1 (3)	1 (2)
雙交 Double	抗BL親本臺農67號等雙交15組合 ($TNG67^n$/BL resist.)[2]	420 (62)	23 (3)	29 (5)	204 (30)	291 (66)	69 (15)	60 (14)	22 (5)	25 (100)	0	0
回交 Back	回交臺農67號交抗BL父本回交三次，6組合 $TNG67^4$/BL resist.	258 (43)	56 (9)	50 (8)	239 (40)	365 (66)	99 (18)	54 (10)	36 (6)	44 (100)	0	0

1. 0，+，++，+++＝擬穗稻熱病無，1穗、2穗至約半數穗及一株約有$\frac{1}{2}$至全部稻穗罹病。
 Respectively, 0, 1, 2 to $\frac{1}{2}$ number and $\frac{1}{2}$ to all panicles per plant showing PBL like disease.
2. n, 4n(?), 以形態性狀鑑別。
 Idenfied by morphological traits.

表7. AC_1S_0 個體擬穗稻熱病與 AC_1S_1葉稻熱病之關係

Table 7. Relation between PBL like disease in AC_1S_0 plants and the LBL in AC_1S_1 lines of rice.

材料來源 Origin	AC_1S_0[1] 擬穗稻熱病	AC_1S_1 二期作旱田病圃稻熱病[2]									
		1	2	3	4	5	6	7	8	9	Total 計
TNG67/ TNGY8005	0	16	5	3					12	4	40
	+	4	2	1				1	10	2	20
	++	3	2						8	4	17
	+++	1							2		3
	計 Total	24	9	4				1	32	10	80
雙交15組合 15 double crosses	0	212	7	4	6	2		2	8	43	284
	+	34	1		1			1	2	29	68
	++	16								39	55
	+++	1							2	14	17
	計 Total	263	8	4	7	2		3	12	125	424

1. Degrees of PBL like disease at AC_1S_0 in the first crop.
2. Degrees of LBL at AC_1S_1 in the upland BL nursery of the second crop.

為進一步明瞭上述疑點，將二倍體AC_1S_0個體的擬穗稻熱病發生情形與其後裔AC_1S_1系統於下（第二）期作在旱田病圃的葉稻熱病發生情形做比較，結果示如表7。以 TNG67/TNGY8005 組合而言，AC_1S_1系統的葉稻熱病很清楚的分離為1比1，亦則TNGY8005的葉稻熱病抵抗性乃由一對抗病基因所控制。然而在AC_1S_0調查的擬穗稻熱病各級均有葉稻熱病「抗」與「感」系統出現（表7）。故所謂擬穗稻熱病與葉稻熱病可能沒有相關關係。同樣情況在雙交15個組合的AC_1S_0及AC_1S_1也可以看出（表7）。此雙交材料是以回交育種將稻熱病抵抗性引入於臺農67號後互交，然後再複交而所得之F_1。其AC_1S_1系統在葉稻熱病旱田病圃也很明顯的分離為「抗」與「感」之品系，分離比為「抗」比「感」約2比1（表7）。假如互交系統的稻熱病抵抗性都是顯性而又是源自不同基因，則所得AC_1S_1應該很少有感病系統。另一方面複交F_1必然有分離現象，採幼穗做花藥培養時，難免有取樣的機差，故比較難做正確的分析。不過稻熱病抵抗性基因確累積在複交AC_1S_1系統，但累積基因的範圍並無想像中之廣。另一方面雙交15組合於AC_1S_0的擬穗稻熱病各級個體均於下（AC_1S_1）一代有葉稻熱病「抗」與「感」系統之分離（表7）；此與 TNG67/TNGY8005 組合完全相同，指示兩種病並無相關關係。

以上AC_1S_0個體於一期作的擬穗稻熱病與二期作旱田病圃AC_1S_1系統的葉稻熱病似無相關關係，其原因可能有二。一為擬穗稻熱病根本非起因於稻熱病病菌，是其他病菌所引起者。另一是第一期作的穗稻熱病菌生理小種與二期作的葉稻熱病病菌不同。為明瞭此問題，擬與植病專家合作進一步探討此問題。

本育種計畫以合併稻熱病及褐飛蝨抵抗性為主要目標，且此等抵抗性在一般田間能維持愈久愈好。按花藥培養後代的標誌基因依照正常的遺傳法則分離及重組[7]，而本試驗的稻熱病抵抗性與褐飛蝨抵抗性也同樣有明顯的重組現象（表8），雖然由其分離比尚難估計有多少對基因在作用。從這些新育成之AC_1S_2品系選得抗稻熱病及褐飛蝨而植株型靠近臺農 67號之新品系，應該沒問題。將來若有更多此類組合之雜交，則選到株型更好而抗多種病蟲害之品系應該會更多。故應用花培養的水稻育種是相當樂觀的。

表8. 兩個水稻F_1的AC_1S_1系統稻熱病及褐飛蝨抵抗性之分離（民73年二期作）

Table 8. Segregations of blast and brown planthopper resistances in the AC_1S_1's of two crosses of rice (1984—II).

雜交組合 Cross combination	母本 ♀		父本 ♂		AC_1S_1 系統數 Line No.				
					BL, R		BL, S		Total 計
	BL	BPH	BL	BPH	BPH, R	BPH, S	BPH, R	BPH, S	
TNG67/TNGY8005	S	S	R	R	9	28	16	27	80
TNG67/TNG69	S	S	R	R	4	12	7	6	29

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Application of Anther Culture to Rice Breeding[1]

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Summary

Two groups of *japonica* rice strains were yield-trialed, i. e. those selected from the progenies of anther-cultured (AC) hybrids and those from the ordinary pedigree method but of different cross origin. The two groups showed a similar yield performance in the first rice crop but not in the second crop. The AC group tended to be low in the seedset percentage and panicle weight than the pedigree group in the second crop, hence it gave a significantly low number of high-yielding strains. The results of selection on the AC lines from the single cross, double cross and backcross hybrids indicated that the single cross hybrid seemed to be most suitable for the breeding using anther culture, since its genetic background was relatively simple and there was no difficulty in obtaining the segregate and recombinants of the desirable characters such as blast and brown planthopper resistances through this in-vitro procedure.

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水稻臺農67號大粒 isogenic 系統之育成初報[1]

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摘要　以糙米百粒重 2.0 g 左右之臺農67號及 3.5 g 左右之 Pegonil 兩品種爲親本，其正反交之兩 F_1 後代再與輪迴親本臺農 67 號連續回交，期育成臺農 67 號大粒 isogenic 系統。本文即在初步報導此育成過程中之若干結果。F_1 數據顯示糙米百粒重無正反交之差異。TNG 67/Pegonil/TNG 67 集團糙米百粒重平均爲 3.09 g，集團常態分布於兩親本間；反之，Pegonil/TNG67^2 之糙米百粒重僅達 2.29 g，集團分布集中且靠近輕百粒重親本臺農67號。穗數、一穗穎花數及單株糙米產量等重要性狀 TNG 67/Pegonil/TNG 67 集團者均較Pegonil/TNG 67^2 集團者爲低。綜合考慮此等初步結果認爲育成臺農67號大粒 isogenic 系統以繼續臺農67號爲母本之後代集團之選株連續回交輪迴親臺農67號較有希望。

臺灣近年來雖因稻穀生產過剩而積極推行稻田轉作，但一個個更豐產稻品種之育成仍是稻作育種之最重要目標之一，更是稻育種工作者最主要之挑戰。要增加水稻之產量可經由提高產量構成要素中之任一個，但不影響其他要素之表現而達成。亦即由於各產量構成要素間具互相牽制作用，妥善調整諸性狀之表現才能穫致高產[14]。Ishizuka[11] 提出水稻產量達 6t/ha 之最理想組合是，穗數爲每平方公尺400支，一穗穎花數爲 80個，結實率爲 85%，千粒重 22g。在臺灣地區，一期作水稻之穗數已被認爲合理[17]，尤以目前機插密植的栽培方式，欲求再增加穗數可能有困難，且目前推廣品種一期作之一穗穎花數在100個以上及結實率在 90% 以上者比比皆是。換言之，經由改良這些性狀以求增產可能也不易有突出之效果。

水稻之粒重受內、外穎之體積限制[14,18]，是最穩定的品種特性之一[9,14,18]。IRRI 世界性蒐存14,128個稻種源單穀粒重之變域介於 6—52 mg 之間[9]，一般栽培品種之單穀粒重多在 25 mg 左右。國外生理學者比較大小粒品種穀粒充實成熟期間之穀粒充實速率 (grain filling rate) 及穀粒充實期間 (grain filling duration) 等的穀粒充實介量 (grain filling parameters)，獲知穀粒充實速率與期間與穀粒大小 (grain zize，即粒重) 成顯著之正相關，且充實速率又較充實期間重要[8,9,10,13,15]。而穀粒充實期間大粒品種之澱粉累積較小粒品種更具效率、產量潛能 (yield potential)、積儲對供源比 (sink-to-source ratio，開花時之產量潛能與葉面積指數之比值) 並皆以大粒種爲佳[9,10]，指出較大穀粒之選拔是提高現有品種產量潛能之一可能途徑[10]。並估出達最高產量潛能之合適穀粒大小爲千粒重 39 g[10]。國內本所生理研究室指出，臺中地區一期作水稻成熟時，莖稈所含非構造性碳水化合物 (total nonstructural carbohydrates, TNC) 量最高可達全株總量之 20%，因而認爲如能增大穗部容積，產量應有再大幅提高之可能[16]，經進一步比較大及中粒種稻穀粒充實期間的淨乾物質與非構造性碳水化合物之生成量，獲證兩類品種穗部主要成分之絕對轉流量以大粒品種爲佳。該室綜合其系列研究建議，經由增大穀粒體積謀求稻作增產有其理論基礎[17]。

目前筆者等蒐集到的有關穀粒大小與產量潛能關係之文獻中，僅 IRRI[10] 係以千粒重分別爲

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16.5 g 及 19.1 g 之 isogenic 系統爲材料外，餘均爲遺傳背景完全不同之不同粒重之水稻材料，故認爲有關穀重與產量潛能間之推論應是大粒品種整個基因型（genotype）與小粒品種基因型之差異，而不能以粒重之不一來完全解釋，而 IRRI 之千粒重分別爲 16.5 g 與 19.1 g 之 isogenic line 之研究，其穀粒大小又嫌過小，故有育成目前栽培面積最廣臺農 67號大粒 isogenic 品系，以探討（1）在極類似之遺傳背景下，從生理方面理論地檢討大粒品系之高產潛能，（2）在實際的田間栽培下，是否能使水稻成熟時尚殘留於莖稈之非構造性碳水化合物能轉流到大粒品系之較大積儲來，即印證 Wei *et al* [16] 所指一期作積儲是產量抑制因子，如能增大穗部容積，產量應可提高之假說。

材料與方法

一、親本選擇：

考慮抽穗前穗發育與營養器官光合產物之分配，IRRI [10] 建議現存大粒品種須降低株高，Fujita *et al.* [8] 亦認爲現有可利用大粒品種株高概太高，而易於抽穗後倒伏，致不易於生育至成熟間正確地評估它們之產量潛能，因此建議最好能育成短稈大粒之品種，以利大粒品種產量潛能之田間評估。魏及劉 [5] 也指出應選取短稈與分蘖性强之大粒種源爲育種材料。由於株高關係收穫指數、生長期間（growth duration）、氮肥反應及倒伏抵抗性，向被認爲是一種很重要的性狀，據 Chang and Li [7] 及 Jennings *et al.* [12] 對水稻株高遺傳研究之綜論而知，水稻株高之遺傳研究實詳盡且具體，其遺傳行爲則簡單中也複雜，爲避免不必要之麻煩，故決定入選諸大粒親本中，短稈之大粒品種爲最優先，而因爲我們蒐存到之大粒種源中，短稈者全爲較早熟者，在幾次初步之田間觀察並配合文獻之檢討後，決定選用稻穀千粒重約爲 45 g（換算成糙米約 36 g）左右，株高 95 cm 之 Pegonil（引自臺中區農業改良場）。已知穀粒越大，每穗穎花數越少 [8]，且大粒品種常伴有穗數較少之缺點（田間觀察未發表資料），爲補救此大粒品種已知之弱點及避免大粒品系由於穗重較重可能較易導致倒伏之缺憾，另一親本我們選用植株亦矮，强稈不倒伏目前被廣爲栽培的豐產品種臺農 67 號 [3]，當然臺農67號本身仍有若干缺點，但因臺農67號適應性廣，耐粗放栽培、偏向穗數型，故在目前尚無其他更理想的短稈多穗抗倒伏之粳稻品種之情況下，臺農67號被認爲是最佳之另一親本。

二、育成方法：

採回交育種法，然據 Chang and Somrith [6] 及 Chang Li [7] 之綜論，曾有報告指出粒重有母系效應（maternal effect）存在，爲避免此母系效應問題，1983 年 2 期作進行第 1 次交配時，臺農 67 號與 Pegonil 分別各爲母本，即正反交，因得雜交 F_1 種子兩組，兩組之雜交 F_1 種子均各分成兩部份，一部份供1984年 1 期作與兩親本作田間之農藝性狀評估，另部份供與輪迴親本臺農67號回交用，所得兩組回交第 1 次 F_1 代種子仍分成兩部份，一部份供農藝性狀評估，另一部份依回交育種法回交，重複此農藝性狀評估與回交輪迴親本臺農67號至必要之代數。至此足够代數後，使回交植株行自交一次，在其後裔中選拔。據 Chang and Somrith [6] 及 Chang an Li [7] 之綜論，郭及謝 [1] 及曾 [2] 研究已知粒重之遺傳屬數量性狀，且有非對立因子之交感效應（nonallelic interaction effect）現象，遺傳行爲並不很簡單，但因狹義遺傳率頗高，選拔當具效率。故擬連續回交 10 次以上，唯將視每回交代農藝性狀之田間評估之成績靈活運用之。

結　　果

母系效應通由供試品種（系）正反交 F_1 世代各性狀之表現判定之。本育成工作曾事先考慮及此問題，故首要之工作重點即在偵測母系效應之有無，而因爲水稻 F_1 植物之遺傳型雖爲異質結合體（heterozygote），但 F_1 當代植株却與純系（pure lire）的兩雜交親本同爲不分離世代，故意在檢驗有無母系效應之1984年 1 期作 F_1 世代農藝性狀之田間評估正反交兩組 F_1 集團暨兩親本均僅調查40株。農藝性狀調查項目及結果列於表 1。由表 1 知，兩親本之糙米之百粒重、粒長、粒寬及粒厚、株

高、每株穗數、一穗穎花數及結實率等8個調查性狀均有顯著差異。一般言，臺農67號植株高於Pegonil，每株穗數及一穗穎花數亦以臺農67號較優，但結實率及糙米性狀則Pegonil較佳，其中Pegonil之糙米百粒重幾達臺農67號者之兩倍。正反交兩組 F_1 集團調查性狀中，兩組 F_1 集團表現不盡相同，但達5%顯著水準者儘株高一性狀而已。就中兩組 F_1 集團之株高、每株穗數及一穗穎花數則表現出一特異之趨勢，即此3性狀之表現均較趨向花粉親，換言之，前述3性狀田間評估之結果並未發現母系效應存在，最受注目之性狀糙米百粒重兩組 F_1 集團之平均分別爲 2.74 g 及 2.79 g，均略高於兩親中間值之 2.68 g，爲大粒親本 Pegonil 之80%左右。

表 1. 兩親本與正反交 F_1 集團各性狀在1934年一期作之表現

Table 1. Performance of various characters of parents, TNG 67/Pegonil and Pegonil/TNG 67 populations, 1984 1st crop

Population	Plant height (cm)	Panicle number/hill	Spikelet number/panicle	100-grain weight of brown rice (g)	Seed setting (%)	Brown rice Grain length (mm)	Brown rice Grain width (mm)	Brown rice Grain thickness (mm)
TNG 67	102.7a[1] (100)	12.0a (100)	105.6a (100)	1.90c (55.1)	74.0b (93.1)	4.87c (65.3)	2.90c (89.5)	2.04b (91.9)
Pegonil	96.1b (93.6)	8.6c (71.7)	71.4c (67.6)	3.45a (100)	79.5a (100)	7.46a (100)	3.24a (100)	2.22a (100)
TNG 67/Pegonil	96.5b (94.0)	10.6b (88.3)	87.1b (82.5)	2.74b (79.4)	69.0c (86.8)	5.83b (78.2)	3.08ab (95.1)	2.19a (98.6)
Pegonil/TNG 67	101.5a (98.8)	11.1ab (92.5)	95.9b (90.8)	2.79b (80.9)	70.5c (88.7)	5.77a (77.3)	3.10ab (95.7)	2.22a (100)

1: Means in each column with the same letter are not significantly different at 5% level.
TNG 67: Tainung No. 67.

正反交兩組 F_1 植株於1984年1期作與輪迴親臺農67號第一次回交，兩組第1次回交集團與兩親於1984年2期作之田間評估結果列於表2至表5。表2是兩親本及兩第1次回交集團糙米百粒重之頻度分布表。比較表1及表2兩親本糙米百粒重知，兩本在二期作環境條件下之糙米百粒重均較一期作條件下好，但臺農67號糙米百粒重與大粒品種 Pegonil 糙米百粒重之比率則相近，概55%左右。TNG 67/Pegonil/TNG 67 集團糙米百粒重之頻度分布呈連續性單峰分布，變域頗廣由百米重2.00 g至 4.25 g，尖峰介於 3.0 g 至 3.25 g 之間（穀粒 3.75 g 至 4.07 g），集團平均糙米百粒重3.09 g（穀粒3.87 g），約爲大粒親本之82.3%。另一回交集團 Pegouil/TNG67[2] 糙米百粒重之頻度亦爲單峰之連續分布，但變域則頗狹色於 1.75 g 至 3.98 g 之間，尖峰出現在 2.0 g 至 2.25g之間，集團平均糙米百粒重 2.29 g（穀粒 2.87g），爲大粒親本之 61.2%。比較 TNG67/Pegonil 及 Pegonil/TNG 67 與 TNG 67/Pegonil/TNG 67 及 Pegonil/TNG 67[2] 糙米百粒重對大粒親本糙米百米重之比率發現，以臺農67號爲毋本這組材料，TNG 67/Pegonil（即 F_1 代）之比率爲79.4%，TNG 67/Pegonil/TNG 67（即回交第1代）之比率却升爲82.6%。反觀 Pegonil/TNG 67當代之比率爲 80.8%，略高於 TNG 67/Pegonil 者，但 Pegonil/TNG 67[2] 却降至61.2%。

已知大粒品種有每株穗數及一穗穎花數均較少之事實[8]，故詳列該2性狀之頻度分布表供檢討。由表3顯示，臺農67號在1984年兩個期作狀況下，每株穗數之表現極穩定，也許這是它產重穩定之原因之一。大粒親本 Pegonil 之穩數則2期作較1期作略有增加。TNG 67/Pegonil/TNG 67 及 Pegonil/TNG 67[2] 兩集團之每株穗數的頻度分布十分類似，均呈連續性分布，尖峰均在每株穗數 11—13 支間。TNG 67/Pegonil/TNG 67 集團平均每株穗數在11.1支，爲親本臺農67號之 88.8%，

表 2．4 個集團糙米百重在1984二期作之變異

Table 2. Variation of 100-grain weight of brown rice of parents, TNG 67/Pegonil/TNG 67 and Pegonil/TNG 67 Populations, 1084 2nd crop

Population	100-grain weight of brown rice (g)											Total	Mean	CV. (%)
	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00	4.25			
TNG 67	11	29										40	2.07 (55.3)	2.98
Pegonil							5	18	13	4		40	3.74 (100)	5.13
TNG 67/ Pegonil/ TNG 67		2	8	53	70	82	54	24	11	1		305	3.09 (82.6)	11.53
Pegonil/ TNG 67^2	18	135	113	27	4							297	2.29 (61.2)	7.94

TNG 67 : Tainung No. 67.

表 3．4 個團穗數在1984二期作之變異

Table 3. Variation of panicle number per hill of parents, TNG 67/Pegonil/TNG 67 and Pegonil/TNG 67^2 populations, 1984 2nd crop

Population	Panicle number per hill											Total	Mean	CV. (%)
	3	5	7	9	11	13	15	17	19	21	23			
TNG 67			1	10	18	10	1					40	12.5 (100)	13.68
Pegonil		6	14	16	3	1						40	9.4 (75.2)	20.85
TNG 67 / Pegonil/ TNG 67	14	40	56	52	63	46	23	5	5	1		305	11.1 (88.8)	32.22
Pegonil/ TNG 67^2	3	12	32	80	83	54	21	8	2	2		297	12.1 (96.8)	24.97

TNG 67 : Tainung No. 67.

Pegonil/TNG 67^2 集團之平均每株穗數爲12.1支，爲臺農67號之96.8%。已知 Pegonil/TNG 67^2 及 Pegonil/TNG 67 之每株穗數分別爲臺農67號之88.4%及92.5%（表 1），比較 TNG67/Pegonil 與 TNG 67/Pegonil/TNG 67 及 Pegonil/TNG 67 與 Pegonil/TNG 67^2 每株穗數之變化，可知回交一次對 Pegonil/TNG 67 穗數之影響遠大於其對 TNG 67/Pegonil 者。

表 4 爲兩親本及兩第 1 次回交代之平均一穗穎花數之頻度分布表。由表 4 知兩親本在二期作一穗穎花數之表現均較一期作者佳，臺農67號增加之幅度較 Pegonil 爲著，而二期作 Pegonil 一穗穎花數對臺農 67 號者之比率却反較一期作者爲低。TNG 67/Pegonil/TNG 67 集團之變域甚狹，幾與大粒親本 Pegonil 相同，唯集團一穗穎花數頻度分布之尖峰是在每穗 80—95 個穎花之間，大粒親本Pegonil 者則在每穗 65—80 個穎花之間。本 TNG 67/Pegonil/TNG 67 集團之一穗穎花數之平均爲86.2個與 TNG 67/Pegonil 相近，但對各該期作親本臺農67號之比則 TNG 67/Pegonil/TNG 67 集團遠低於 TNG 67/Pegonil 世代。Pegonil/TNG 67^2 集團一穗穎花數之變域甚廣，頻度分布之高峰在每穗110—125個穎花之間，集團平均爲每穗115.4個穎花。其佔當期作親本臺農67者者之比率

表4．4集團一穗穎花數在1984年二期作之變異

Table 4. Variation of spikelet number perpanicle of parents, TNG 67/Pegonil/TNG 67 and Pegonil/TNG 67^2 populations, 1984 2nd crop

Population	Spikelet number per panicle									Total	Mean	CV. (%)
	50	65	80	95	110	125	140	155	170			
TNG 67			7	13	15	5				40	124.6 (100)	9.71
Pegonil	1	35	4							40	73.8 (59.2)	9.98
TNG 67/Pegonil /TNG 67	16	115	139	2						305	86.2 (69.2)	18.12
Pegonil/TNG 67^2		7	43	82	84	52	18	4		297	115.4 (92.6)	17.56

TNG 67 : Tainung No. 67.

表5．4集團若干性狀在1984年二期作之表現

Table 5. Performance of various characters characters of parents, TNG 67/Pegonil/TNG 67 and Pegonil/TNG 67^2 populations, 1984 2nd crop

Population	Brown rice		Seed setting	Yield of brown rice
	Grain length (mm)	Grain Width (mm)	(%)	per hilll (g)
TNG 67	4.99 (67.3)	2.98 (94.3)	89.4 (96.3)	27.2 (100)
Pegonil	7.42 (100)	3.16 (100)	92.8 (100)	20.2 (74.3)
TNG 67/Pegonil/TNG 67	6.62 (89.2)	3.14 (99.4)	86.1 (92.8)	18.8 (69.1)
Pegonil/TNG 67^2	5.42 (73.0)	3.01 (95.9)	82.8 (89.2)	25.2 (92.6)
Mid-parents	6.21 (83.7)	3.07 (97.2)	91.1 (98.2)	23.7 (87.1)

TNG 67 : Tainung No. 67.

達92.6%，高於 Pegonil/TNG 67。回交對 TNG 67/Pegonil/TNG 67 及 Pegonil/TNG 67^2 兩集團每穗穎花增進於效果似完全不同。

兩親本 TNG 67 及 Pegonil 與兩第1回交代 TNG 67/Pegonil/TNG 67 及 Pegonil/TNG 67^2 集團之糙米粒長、粒寬、結實率及單株產量之表現如表5。由表5知， Pegonil/TNG67^2 集團糙米之粒長、粒寬及結實率地低於中間親本，但單株糙米產量則高於中間親本而接近豐產中粒種親本。TNG 67/Pegonil/TNG 67 集團糙米之粒長、粒寬均高於中間親本，結實率及單株糙米產量均遠低於中間親本。其中，TNG 67/Pegonil/TNG 67 集團之平均單株糙米產量甚至低於其大粒親本 Pegonil，考其原因應是 TNG 67/Pegonil/TNG 67 集團之每株穗數及一穗穎花數雖較其大粒親本Pegonil略多，但結實率與糙米百粒重遠較Pegonil爲低之故。

討　論

遠在民國67年本所前水稻育種專家鄧耀宗先生即有育成豐產飼料米之議；日本育種界則認爲大粒種源之利用可能爲超多收飼料米育種之可行方法之一[4]。國內外生理學者也一致認爲大粒種源之產量有其潛能[5,8,9,10,16,17]。經詳細之文獻研讀與初步之田間觀察比較，認爲育成臺農67號大粒isogenic line 爲提供此理論與實際問題解決之最佳實證。臺農67號大粒 isogenic line 之育成工作尚在起步階段，但從初步有限之資料中發現糙米百粒重正反交間無顯著差異存在（表1），但此正反交兩類F_1經與輪迴親臺農67號行第1次回交後，以大粒品親本 Pegonil 爲母本之系統，其糙米百粒重由F_1代（即 Pegonil/TNG 67）之2.79 g（爲當期作大粒親本之80.9%，表1），迅速降爲 Pegonil/TNG 67^2 之 2.29 g（爲當期作之大粒親本之61.2%，表2）。而以中粒種臺農 67號爲毋本之系統，其 F_1 代（即 TNG 67/Pegonil）糙米百粒重却由2.74 g（爲當期作大粒親本之79.4%），增加爲TNG 67/Pegonil/TNG 67 之3.09 g（爲當期作大粒親本之82.6%）。此 Pegonil/TNG 67 經回交 TNG 67 後糙米百粒重隨之大幅降低之結果，我們從回交育種理論上之考慮很願意接受這事實，但另方面，經一項回交中粒種臺農67號，TNG 67/Pegonil 之糙米百粒重却反而增加，增幅達3%，此現象則尚無合理解釋。

Pegonil/TNG 67 經回交輪迴親本中粒種臺農 67 號以後，穗數及一穗穎花數均大有增加（表1、表3及表4），單株糙米產量亦與豐產品種相近（表5），但考慮到糙米百粒重僅2.29 g（表2，合稻穀百粒重約2.85 g左右），認爲繼續回交輪迴親本臺農67號則目標粒重（糙米百粒重 3.0 g）之臺農67號大粒 isogenic line 出現之頻度應近乎零。故未再大量進行回交工作以獲致大量種子，俾進行再次之田間評估與回交等兩部份工作之須，少量種子僅擬小型田間觀察確證後，以大粒種 Pegonil 爲毋本之回交系統即擬放棄而全力投入以中粒種臺農67號爲毋本之回交系以竟全功。

以臺農 67 號爲毋本之回交系統，糙米百米重不因回交而降反增而爲吾大所樂見已如前述，但 TNG 67/Pegonil/TNG 67 之一穗花數之數目雖較 TNG 67/Pegonil 世代者略有增加（表1及表4），但對各該期作臺農67號者之比率，TNG 67/Pegonil/TNG 67 集團者反較 TNG67/Pegonil 世代者爲低，由此現象推測吾人擬藉連續回交輪回親本臺農76號而迅速提高本回交系之一穗穎花數至目標數目可能非短期間內可達到。穗數之表現亦類似一穗穎花數之變化。TNG 67/Pegonil TNG 67 集團一穗穎花數對該期作臺農67號者之比率較 TNG 67/Pegonil 世代者略有增加，但幅度則甚低。綜合考慮以臺農 67 號爲毋本初期世代之糙米百粒重及其他產量性狀之表現，選獲合意臺農 67 號大粒 isogenic line 之期間可能不會太短。

另因供試材料之糙米百粒重未發現毋系效應，而株高每株穗數及一穗穎花數等3性狀之表現均較趨向花粉親（表1）。

故若全面考慮表1至表5全面資料，保留全部數據不動，但將 TNG 67/Pegonil 與 Pegonil/TNG 67 互調位置，TNG 67/Pegonil/TNG 67 與 Pegonil/TNG 67^2 互調位置，則株高、每株穗數及一穗穎花數及糙米粒重之毋系效應結果則顯現出來。由於第一次行正反交時（即TNG 67/Pegonil 及 Pegonil/TNG67 F_1 雜交時），同時進行之雜交組合很多，其他組合至目前並未發現類似現象，故針對此點已重新於1984年2期作開始再次如操作，以確定結束並做進一步之瞭解。

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A Pereliminary Report on Developing Larger-seed Isogenic Line of Rice Variety, Tainung No. 67[1]

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Summary

The present experiment is aimed to develop the larger-seed isogenic line of Tainung No. 67 (TNG 67), which is now the most popular variety in Taiwan. In the F_1 crosses between TNG 67 (2.0g/100-brown-rice) and Pegonil (3.5g/100-brown-rice), no significant difference was observed in sees size between the reciprocal crosses. In the BC_1 generation of TNG 67/Pegonil/TNG 67, seed size distributed normally with a mean value of 3.09 g/100-brown-rice. However, in the population of Pegonil/TNG 67^2, seed size distributed skewly toward TNG 67 with a smaller mean value of 2.29 g/100-brown-rice. Characters such as panicle number per hill, spikelet number per panicle and bro wnrice yield per plant in the population of TNG 67/Pegonil/TNG 67 were all found to be smaller than those in the population of Pegonil/TNG 67^2.

From this preliminary study, it is conclued that developing a larger-seed isogenic line of Tainung No. 67 by repeated back cross and using TNG 67 as the recurrent parent and Pegonil as the donor parent should be promising.

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氮肥、行株距與每欉苗數對水稻新品種（系）產量及農藝性狀之影響[1]

曾　東　海[2]

摘要　民國73年第一期作，以雙重裂區設計，舉辦氮肥量(221, 174kg/ha)、行株距(28×20, 25×20, 28×16, 25×16cm）及每欉苗數(單本植、3本植、5本植）對臺農秈糯2號、臺農秈育19號、臺中秈3號及臺中在來1號等水稻品種(系)之影響試驗，其結果摘要如下：

稻穀產量因品種、行株距、每欉苗數之不同而有顯著的差異，且受氮肥量與行株距、氮肥量與品種、品種與每欉苗數等之交感效應影響。穗數受氮肥量、品種（系）及每欉苗數之影響顯著或極顯著；穗長、穗重及一穗穎花數則受品種及苗數影響極顯著；千粒重與稔實率則受品種影響極顯著，而受栽培試因影響不大。

影響產量之主要構成因素爲千粒重與稔實率，呈極顯著的正相關；穗數與穗長、穗重、一穗穎花數及千粒重呈極顯著之負相關，穗數與稔實率呈顯著之負相關；一穗穎花數與穗長，穗重及千粒重呈極顯著之正相關；稔實率與穗長呈負相關，與穗重呈正相關。

臺農秈糯2號與臺農秈育19號之產量平均分別爲6,487及6,559 kg/ha，均顯著高於臺中秈3號及臺中在來1號，受每欉苗數及氮肥量影響較大，而行株距之影響較小。臺農秈糯2號以5～6支苗插植，施用重肥，產量較高。臺農秈育19號宜以5支苗插植，但在重肥或密植時，則以3支苗插植較佳。

稻米產量係由單位面積穗數，一穗穎花數，稔實率及千粒重等共同決定。這些產量構成因素與栽植之行株距，施肥量及品種均有密切的關係[1,2,7,9,11,12,13,16,17,18]。因此選擇優良品種及應用各種栽培技術，提供水稻最適當的生育條件，使單位面積有最多的穗數，增加每穗的穎花數，並提高稔實率與千粒重，是爲水稻增產的主要途徑。

根據統計，全省每公頃平均之糙米產量在1960年爲2,495kg，1970年爲3,173kg，1980年爲3,692 kg[8]。單位面積產量逐年提高，20年之間提高48%。單位面積產量的增加，除了採用高產的優良品種外，栽培方面則趨向重肥與密植之應用。栽培密度，因地區及品種不同而異，目前本省一般手工插秧之行距爲22～25cm，株距爲20～24cm，即每公頃17萬3千到20萬欉，在臺南地區更有25×14cm（每公頃27萬8千餘欉）之高密度的栽培。機械插秧之行株距通常爲30×16cm或28×16cm（約每公頃21萬到22萬4千欉），即所謂寬行密植之栽培法。就氮肥用量而言，每公頃之氮肥施用量，亦因品種與地區不同而施用不等量的氮肥，通常一期作爲110—160kg，二期作爲80—140kg，半矮性的長秈稻品種，一般皆增加10～20%之氮肥用量[4]。

密植可增加單位面積穗數，但過度密植，單位穗數雖增多，每穗穎花數却相對地減少。適當的密

1.臺灣省農業試驗所　研究報告第 1242 號。本文承蒙黃研究員貞正斧正，並受行政院國家科學委員會獎助，謹致謝意。

2.臺灣省農業試驗所農藝系助理研究員。臺灣省　臺中縣　霧峰鄉。

度可使單位面積穗數增多，且不使穎花數減少，而達增產的目的[9]。肥料三要素中，氮肥易使莖葉生長量迅速增大，分蘗增加，株高較高，因此氮肥超量時，易引起稻株倒伏，影響稻穀產量[7]。水稻的氮肥利用效率隨日射量增大而提高，而稻穀產量受氮肥量影響，因品種株型與栽培密度之不同而有很大之差異[7]。綜合以往關於肥料與栽培密度對水稻之影響報告[5,7,9,11,15,17]，顯示不同的品種對肥料及密度有不同的反應，因此水稻品種必須在其最適當的栽培條件下，才能充分表現其生產潛力。

臺農秈糯2號及臺農秈育19號爲筆者等新育成的水稻新品種（系），皆具有抗稻熱病及抗褐飛蝨的特性。臺農秈糯2號是中短粒型的糯稻品種，於民國73年7月，經農林廳水稻命名審查小組，審查通過而予命名，在一般栽培條件下，平均產量高於6噸／公頃，最高產量可達8噸，比舊有的糯稻品種增產19～37%以上[6]。臺農秈育 19號爲屬於高顆粒性澱粉，適於加工用的秈稻品系，其產量比目前栽培最廣的臺中秈3號高[4]。爲了使臺農秈糯2號及臺農秈育 19號，更能發揮其生產潛力，提高單位面積產量，實有探討其最適當的氮肥用量，種植行株距及每欉苗數的必要，以供農民種植該品種之參考。基於此目的，本所於民國73年一期作舉辦本試驗，所得結果報告於下。

材料與方法

水稻新品系臺農秈育19號（V_1），新品種臺農秈糯2號（V_2）及臺中秈3號（V_3），臺中在來1號（V_4）等四品種（系）爲供試材料。

處理項目有氮肥用量，行株距及每欉苗數等，其變級分別爲二種氮肥要素量：N_1： 221kg/ha及N_2：174kg/ha；四種行株距：D_1：28×20cm, D_2：25×20cm, D_3：28×16cm, D_4：25×16cm；三種每欉苗數：P_1：1本植，P_2：3本植，P_3：5本植。

試驗設計採用雙重裂區，氮肥用量爲大區，行株距爲中區，品種與苗數爲小區，二重複，小區爲5行區。每行種植株數；株距20cm者爲15株，株距16cm者爲19株。

田間之栽培管理，氮肥用硫酸銨〔$(NH_4)_2^-$，含氮21%〕，分別於整地時（25%氮肥加全量的磷肥及75%鉀肥），第一次追肥（20%氮肥），第二次追肥（20%氮肥），第三次追肥（20%氮肥加25%鉀肥）及穗肥（15%氮肥）施用。行株距及每欉苗數按計畫執行，其餘均按一般栽培法管理。調查項目爲抽穗期、株高、穗數、穗長、穗重、一穗穎花數、稔實率、千粒重及稻穀產量。

試驗結果

一、氮肥量、行株距、每欉苗數及品種對產量等性狀之影響

就產量變方分析表（表1）得悉，水稻稻穀產量，受氮肥量之影響不顯著，但行株距，品種及每欉苗數對產量之影響均達極顯著。同時氮肥量與密度、氮肥量與品種、品種與每欉苗數之交感效應亦顯著地影響稻穀產量。

1.氮肥量之效果：二種氮肥用量，對產量無顯著的效果。其產量構成因素中只穗數有顯著差異，即重肥區有較多的穗數，但不致於影響到產量；氮肥量對其他產量構成因素影響不顯著；重肥區之抽穗期略晚，株高略高（表2）。

2.行株距之影響：稻穀產量極顯著地受行株距之影響，平均以28×16cm（D_3）爲最高產（6,243 kg/ha），其次爲25×16cm（D_4）(6,218kg/ha) 顯著優於D_1：28×20cm（6,117kg/ha）及D_2：25×20cm（6,078kg/ha）（表3），由此試驗結果顯示行距28cm之稻穀產量優於25cm者，株距16cm者產量高於20cm 者。行株距對產量構成因素影響不顯著。各行株距處理之平均抽穗期相似，株高只有密植（D_4：25×16cm）略矮2cm，而其他各區相似（表2）。

3.品種（系）間之差異：品種對產量影響極顯著，稻穀產量以臺農秈育19號最高，其次爲臺農秈糯2號，每公頃平均產量分別爲6,559kg及6,488kg，顯著優於臺中在來1號（5,888kg/ha）及臺中

Table 1. Analysis of variance for grain yield and yield components.

Source of variation	D. F.	M. S.				
		Grain yield	Panicle No.	Spikelet No.	Grain wgt.	Seed-set
Block	1	0.0164	6.750	18.070	2.130 *	241.796
Nitrogen levels (N)	1	3.3646	77.521 *	30.642	1.332	97.067
Error (A)	1	0.1286	0.422	6.258	0.012	13.618
Plant spacing (D)	3	0.2975**	43.592	63.465	0.7916	13.590
N×D	3	0.6684**	28.733	197.629	1.320	44.738
Error (B)	6	0.0160	13.096	478.991	0.434	53.338
Variety (V)	3	8.5246**	34.252**	1,520.801**	38.641**	977.114**
N×V	3	0.8596**	16.163	637.997	2.573	7.464
D×V	9	0.0796	4.408	190.475	2.711	28.645
N×D×V	9	0.1025	12.931	299.118	2.763	63.702
Seedlings/hill (P)	2	7.9741**	124.861**	5,938.881**	3.845	10.577
N×P	2	0.2264	5.806	167.653	0.904	58.329
D×P	6	0.0390	8.625	704.130	5.620 *	53.969
N×D×P	6	0.1433	6.382	344.344	1.572	28.166
V×P	6	0.1815 *	9.290	331.962	0.982	36.472
N×V×P	6	0.1044	6.724	164.623	1.579	61.876
D×V×P	18	0.1156	5.352	214.252	1.012	33.898
N×D×V×P	18	0.0875	3.044	115.550	6.877	33.392
Error (C)	88	0.0815	7.619	300.116	2.461	52.818

* Significantly at 5% level.

** Significantly at 1% level.

秈 3 號(5 ,721kg/ha)(表 3)。每欉穗數以臺中在來 1 號最多平均14.08穗，其次爲臺中秈 3 號(13.68穗)，以臺農秈糯 2 號的12.25穗最少。每穗穎花數以臺農秈育19號最多平均 109.31 粒，臺中在來 1 號平均96.82粒最少 ，可見臺農秈育19 號高產是穗重之關係 。千粒重以臺農秈糯 2 號 28.44g最重，臺中在來 1 號26.45g最輕（表 2）；稔實率以臺農秈糯 2 號最高（88%），臺中秈 3 號最低只有77%。抽穗期以臺農秈糯 2 號之82天最早，其次爲臺農秈育19號（83天），而以臺中秈 3 號之89天最晚；株高亦以臺農秈糯 2 號最高（112cm），其次爲臺農秈育19號，以臺中秈 3 號最矮（表 2）。穗長以臺中在來 1 號最短（20.58cm），其次爲臺農秈糯 2 號（21.13cm）顯著地比臺農秈育19號及臺中秈 3 號短，每穗重以臺農秈糯 2 號最重（2.89g），而以臺中在來 1 號最輕（2.39g）（表 2）。

4.每欉苗數之影響：每欉 5 本植之平均稻穀產量爲6,428kg/ha，顯著地比 3 本植(6,301kg/ha) 及單本植（ 5,763kg/ha ）高產，每欉苗數對千粒重與稔實率之影響亦不顯著，而對穗長、穗重、每欉穗數、每穗穎花數及稻穀產量有極顯著的影響 。每欉 5 本植的穗數 (14.65) 最多，而穗長（20.91 cm）最短，穗重（2.43g）最輕，一穗穎花數（95.57粒）最少（表 2 及 3），而單本植的情形正好與

Table 2. Average values of agronomic traits.

Treatment	Days to Heading	Plant height (cm)	Panicle length (cm)	Panicle weight (g)
Nitrogen levels				
N_1 : 221 kg/ha	86.4	102.9	21.4 a*	2.66 a*
N_2 : 174 kg /ha	83.7	99.0	21.4 a	2.72 a
Spacing (cm)				
D_1 : 28×20	85.1	101.4	21.4 a	2.70 a
D_2 : 25×20	85.5	101.4	21.3 a	2.70 a
D_3 : 28×16	84.6	101.8	21.5 a	2.65 a
D_4 : 25×16	85.1	99.2	21.6 a	2.71 a
Variety				
V_1 : TNGSY 19	83.1	98.5	22.0 a	2.87 a
V_2 : TNGSW 2	82.4	111.7	21.1 b	2.89 a
V_3 : TCS 3	88.9	96.8	22.1 a	2.61 b
V_4 : TN 1	85.8	97.0	20.6 c	2.39 c
Seedlings/hill				
P_1 : 1	86.8	101.5	21.9 a	2.92 a
P_2 : 3	84.9	100.8	21.5 a	2.72 b
P_3 : 5	84.8	100.7	20.9 b	2.43 c

* Means with the same letter are not significantly different at 5%.

Table 3. Average values of yield and yield components.

Treatment	Grain yield (kg/ha)	Panicle No.	Spikelet No.	Grain weight (mg)	Seed-set (%)
Nitrogen leveles					
N_1 : 221 kg/ha	6,296 a*	13.82 a	104.70 a	27.67 a	83.26 a
N_2 : 174 kg/ha	6,032 a	12.55 b	105.50 a	27.84 a	84.69 a
Spacing (cm)					
D_1 : 28×20	6,117 b	13.57 ab	106.09 a	27.59 a	84.40 a
D_2 : 25×20	6,078 b	14.22 a	105.94 a	27.72 a	83.30 a
D_3 : 28×16	6,243 a	12.96 a	103.64 a	27.83 a	83.81 a
D_4 : 25×16	6,218 a	11.98 b	104.74 a	27.88 a	84.40 a
Varieties					
V_1 : TNGSY 19	6,559 a	12.72 bc	109.31 a	28.20 a	85.24 a
V_2 : TNGSW 2	6,488 a	12.25 c	107.60 a	28.44 a	87.62 a
V_3 : TCS 3	5,721 c	13.68 ab	106.68 a	27.93 a	77.39 b
V_4 : TN 1	5,888 b	14.08 a	96.82 b	26.45 b	85.66 a
Seedlings/hill					
P_1 : 1	5,763 c	11.87 c	114.83 a	27.48 a	83.72 a
P_2 : 3	6,301 b	13.03 b	104.90 b	27.96 a	84.44 a
P_3 : 5	6,428 a	14.65 a	95.57 c	27.83 a	83.76 a

* Means with the same letter are not significantly different at 5% level.

5 本植之表現相反，穗數（11.87）最少，而穗長（21.9cm）最長，穗重 （2.92g）最重，一穗穎花數（114.83）最多。單本植之抽穗期約晚 2 天，3 本植及 5 本植的抽穗期則相似，三種苗數對株高之影響極微（表2）。

5.氮肥量與行株距之交感效應：此交感對稻穀產量之影響達極顯著水準（圖1），但對產量構成因素之交感全部不顯著（表1）。由圖1顯示，除了行株距25×16cm 者外，重肥區之稻穀產量均高於普肥區，在施用重肥時，以行株28×16cm者產量最高，每公頃平均6,469kg，以 25×16cm者最低（6,185kg/ha），在普肥區則行株距越小稻穀產量越高，行距 28cm 者在重肥區之稻穀產量優於行距25cm者。而在普肥區則相反，以行距25cm者表現較優。

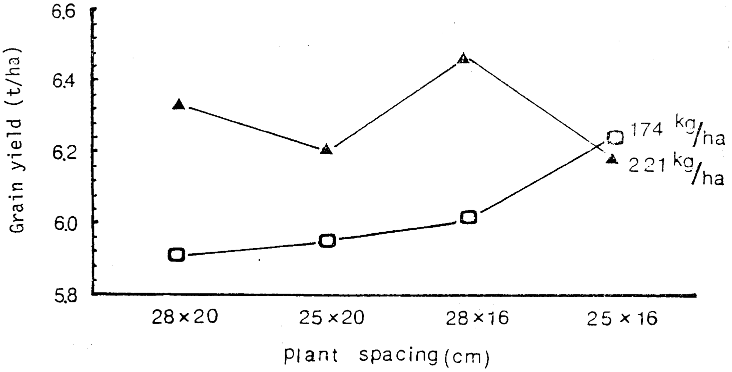

Fig. 1. Average yield of four rice varieties and strains at two nitrogen levels and four planting spacings.

6.品種（系）與氮肥量之交感：不同品種在兩種氮肥量間有極顯著的產量差異（圖2）但對產量構成因素都無顯著的交感（表1）。由圖2顯示臺農秈育19號及臺農秈糯 2 號兩品種（系）對氮肥之肥效較明顯，增施氮肥分別提高產量475及 508kg/ha，達到顯著的增產效果。臺中秈 3 號之肥效較小，增施氮肥時只增產 104kg/ha，而臺中在來1號，於重肥區反而減產，呈現負的肥效。

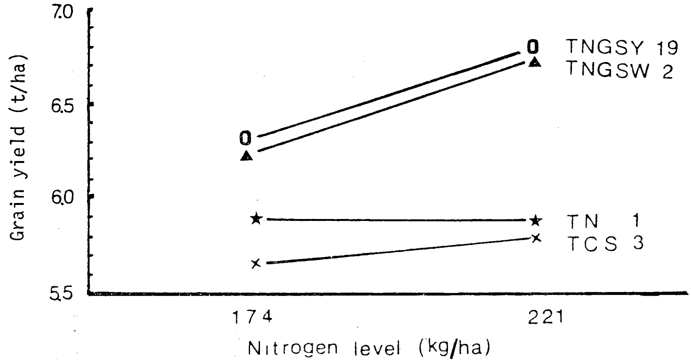

Fig. 2. Grain yield of 4 rice varieties at 2 levels of N fertilization.

7 品種（系）與每欉苗數之交感：不同品種在三種每欉苗數有顯著的產量差異（圖3），而對產量構成因素却無顯著的交感效應。圖 3 顯示臺農秈育19號，臺中秈 3 號及臺中在來 1 號等 3 品種(系)，3 本植比單本植之產量高，每公頃增產 508～776kg，5 本植對 3 本植之增產效果較小，每公頃只增產 50～154kg，而每欉苗數在臺農秈糯 2 號之增產效果是近似直線的增產效果，3 本植比單本植

及 5 本植比 3 本植分別增產274kg/ha（4.3%）及209kg/ha（3.2%）。

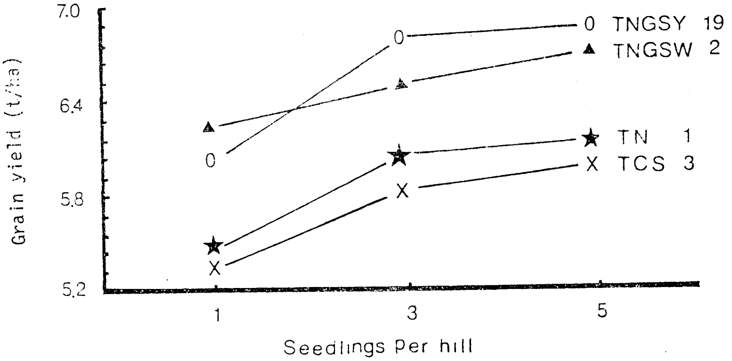

Fig. 3. Grain yield of 4 rice varieties at 3 levels of seedling number per hill for transplanting.

二、產量與產量構成因素之關係

就本試驗所獲得之產量及產量構成因素等資料，進行相關分析，結果如表 4。每欉穗數與穗長、穗重、一穗穎花數、千粒重、稔實率呈極顯著或顯著之負相關，與產量之關係却不顯著；一穗穎花數與穗長、穗重及千粒重呈極顯著之正相關，而與稔實率及產量之相關却不顯著；千粒重與穗長、穗重、稔實率及產量都呈顯著或極顯著之正相關；稔實率與穗長呈極顯著的負相關，與穗重及產量呈極顯著之正相關，顯示稔實率較高，千粒重較重者，其稻穀產量也較高。

Table 4. Correlation coefficients between yield and yield components.

Character	Panicle length	Panicle weight	Spikelet No.	Grain weight	Seed-set	Grain yield
Panicle No.	− 0.4280**	− 0.6752**	− 0.5811**	− 0.4599**	− 0.1591*	0.0271
Panicle length		0.6746**	0.7881**	0.2676**	− 0.3352**	− 0.0590
Panicle weight			0.9001**	0.5204**	0.2578**	0.0613
Spikelet No .				0.2489**	− 0.0920	− 0.0923
Grain weight					0.1728*	0.2347**
Seed-set						0.2549**

* Significantly at 5% level.
** Significantly at 1% level.

三、新育成二品種（系）之適宜氮肥量、行株距及每欉苗數

由前述結果得悉氮肥量與品種、品種與每欉苗數之交感效應對稻穀產量之影響顯著或極顯著，顯示不同品種之最適栽培條件應有差異，仍就兩新品種（系）進行各別的分析，分別探討氮肥量、行株距及每欉苗數對此等二個新品種（系）之影響，以供栽培之參考。

1.臺農秈育19號：由臺農秈育19號之產量及產量構成因素之變方分析（表 5）得悉，臺農秈育19號主要受每欉苗數之影響，而氮肥與行株距之效應不顯著。重肥區的稻穀產量平均爲 6,797kg/ha，

比普肥區增產476kg/hg（7.5%），但未達顯著的水準。各行株距之稻穀產量以 D_4（25×16cm）最高，平均每公頃爲6,693kg，與其他三種行株距之產量差異只有 100～200kg/ha，顯示行株距的效應很小。每欉苗數對臺農秈育19號之影響如圖 4 。5 本植之產量最高，平均每公頃產量爲6,851kg ，顯著優於單本植，唯與 3 本植試區差異不顯著。由圖 4 可明顯地看出單本植之一穗穎花數雖最多，但穗數、千粒重及稔實率都偏低，因而影響稻穀產量。3 本植之試區其稔實率雖最高，穗數、一穗穎花數及千粒重却介於中間，因而其產量亦介於中間。

Table 5. Analysis of variance for yield and yield components of rice strain Tainung Sen Yuh 19.

Source of variation	D. F.	M. S.				
		Grain yield	Panicle No.	Spikelet No.	Grain wgt.	Seed-set
Block	1	0.0093	1.1719	232.623	1.125	35.317
Nitrogen levels (N)	1	2.7115	1.1719	20.8086	0.2657	1.231
Error (A)	1	0.0706	12.5052	113.8965	1.5949	45.772
Plant spacing (D)	3	0.1090	4.2274	202.9897	0.4732	22.628
N×D	3	0.1130	29.3802*	139.1732	0.3136	13.222
Error (B)	6	0.0319	6.0747	263.536	0.7748	32.594
Seedlings/hill (P)	2	3.4275**	25.3594**	2,228.3021**	1.1686	9.631
N×P	2	0.3847**	7.3594	378.5897	0.7658	51.019
D×P	6	0.1702*	3.7274	358.1497	3.3443	31.166
N×D×P	6	0.0852	5.5885	114.1611	1.3616	21.036
Error (C)	16	0.0569	3.4063	170.8165	1.5118	35.849

* Significantly at 5% level.

** Significantly at 1% level.

臺農秈育19號之產量除受每欉苗數之影響外，還受氮肥量與每欉苗數，行株距離與每欉苗數之交感效應影響，由圖 5 顯示臺農秈育19號在單本植時，其產量在四種行株距均相似，產量都最低，在行株距 28×20cm或 25×20cm時 5 本植的產量高於 3 本植，而於密植（25×16cm）時，3 本植之產量超過 5 本植，顯示密植時，每欉插植苗數應略少。由圖 6 之苗數與氮肥對臺農秈育19號之交感效應顯示，在重肥區以 3 本植之產量最高，而在普肥區却以每欉 5 本植之產量最高，而且產量與植苗數幾呈直線關係。顯示在普肥區每欉以 5 本或 5 本以上的苗插植，可得較高的產量。而在重肥區則以 3 本植較佳，苗數太多反而會引起減產。

2. 臺農秈糯 2 號：由臺農秈糯 2 號之產量及產量構成因素之變方分析（表 6 ）得悉，臺農秈糯 2 號與臺農秈育19號相似，主要受每欉苗數之影響，氮肥量與行株距之效應不顯著，重肥區的稻穀產量平均6,741kg/ha，比普肥區增產 507kg/ha （8.1%），亦未達統計分析的顯著水準。各行株距之稻穀產量以D_3（28×16cm）最高，平均每公頃爲 6,571kg，比其他三種行株距增產 100～150kg/ha。每欉苗數對臺農秈糯 2 號之影響如圖 4 ，5 本植之產量最高，平均每公頃產量爲 6,718kg，顯著優於單本植，亦與 3 本植試區(6,509kg/ha）差異不顯著；對產量構成因素之影響與臺農秈育19號相似。

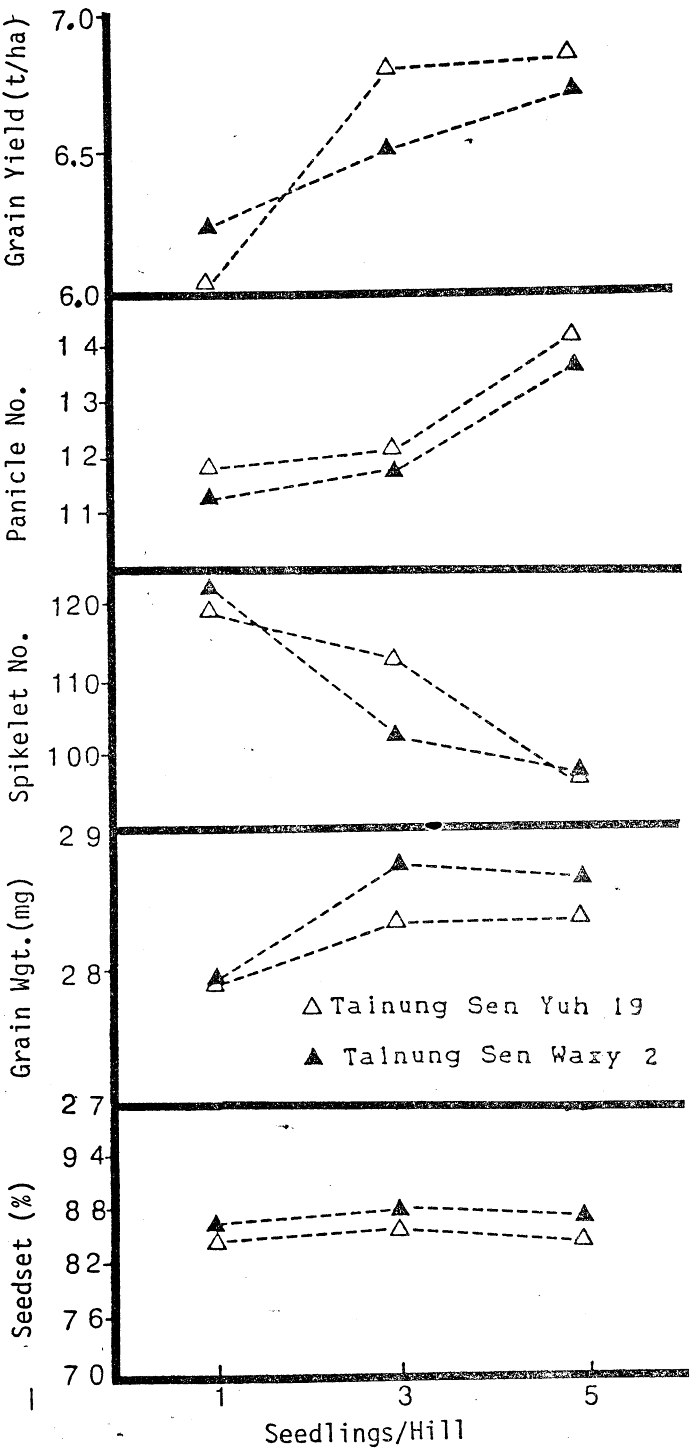

Fig. 4. Effect of seedling number per hill for transplanting on the yield and yield components of rice varieties Tainung Sen Yuh 19 and Tainung Sen Waxy 2.

討　論

氮肥量對水稻產量之影響，依據本試驗的結果，在一般情形下，增施氮肥可提高產量，唯兩種氮肥用量間的差異並未達顯著水準。Chang等 (12) 以嘉農 242 的試驗亦得到相同的結果。

IRRI 報告 (17) 指出某些品種對氮肥的反應通常是不顯著的，就本試驗結果而言，增施氮肥使其增加10%的穗數，但一穗穎花數、千粒重及稔實率却降低，致使產量只增加 4.4%而不顯著（表 3）。

謝等 (9) 指出，密植後雖然每欉穗數減少，但因爲單位面積內總穗數增加，故其產量仍會提高。本試驗亦得到相同的結果，行株距較密的 D_4 (25×16cm) 及 D_3 (28×16cm) 平均每欉穗數較少（11.98及12.96穗），而其單位面積穗數却較多 (299.5及289.3穗 ／m^2)，且因行株距對一穗穎花數、千粒重、稔實率的影響不顯著（表 3），致使其產量顯著高於其他兩處理區。

由表 1 之變方分析顯示，每欉插植苗數，極顯著地影響稻穀產量及穗數、穗重、一穗穎花數等產量構成因素，而千粒重及稔實率受苗數之影響較小，此結果與吳與林 (2) 之報告相似。依據本試驗的結果，3 本植比單本植平均增產538kg/ha (9.3%)，5 本植比 3 本植增產 126kg/ha (2 %)，爲曲線的效應，唯品種間呈現不同的增產效應（圖 3）。由此結果認爲一般插秧以 3 ～

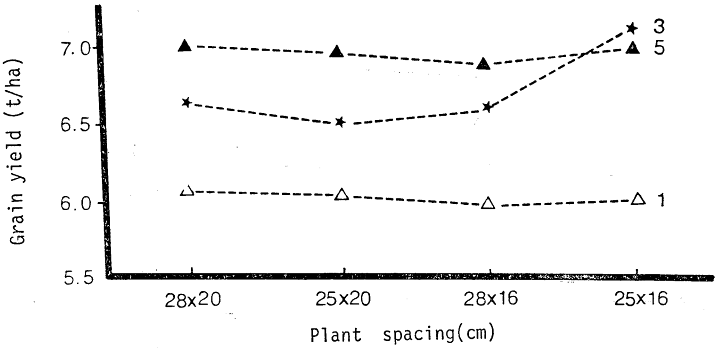

Fig. 5. Grain yield of Tainung Sen Yuh 19 as affected by seedling numbers per hill for transplanting and planting spacings.

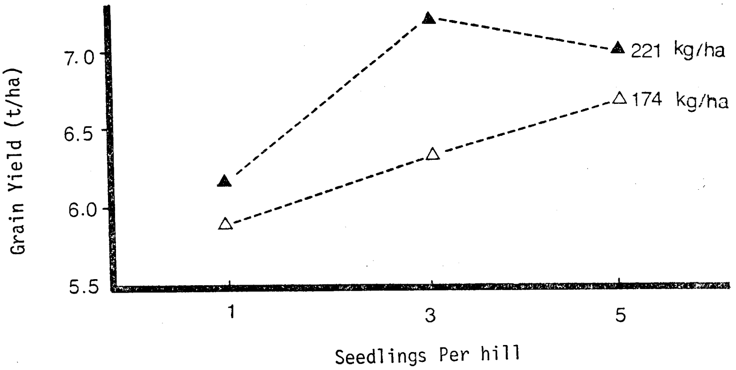

Fig. 6. Yield response of Tainung Sen Yuh 19 to nitrogen levels and seedling numbers per hill for transplanting.

5 本植爲宜，而穗數較少的品種，可略多一點。

臺農秈糯 2 號及臺農秈育19號之穗重，分別爲 2.89及2.87g，顯著地比臺中秈 3 號及臺中在來 1 號重，穗數則較少，但其一穗穎花數較多，稔實率較高，千粒重較重，因而使其稻穀產量（平均分別爲6,487及 6,559kg/ha）顯著高於臺中秈 3 號及臺中在來 1 號（表 3 ）。臺中秈 3 號低產主要爲稔實率偏低所致，而臺中在來 1 號則因一穗穎花數較少及千粒重較輕而低產。

蘇與郭 [10] 指出，水稻氮肥利用率隨日射量增大而增高。依據本試驗的結果，氮肥效應因栽培行株距不同而異（圖 1 ），即提高氮肥量的增產效應，以在D_3（28×16cm）處理區最高，平均增產 452 kg/ha，其次爲D_1（28×20cm）增產 416kg/ha, D_4（25×16cm）試區最差，呈現負效應。此結果顯示行距28cm比25cm 較易得到增肥的效果。密植加施重肥反而減產，其原因可能是密植重肥使莖葉茂盛，空間利用飽和，相互遮蔽，阻礙光合作用，未蒙其利先得弊。而寬行區之遮陰現象較少，得以顯現增肥的效應。

肥效亦因品種不同而異（圖 2 ），臺農秈糯 2 號之肥效最好，重肥區平均每公頃增產 507kg (8.1%)，其次爲臺農秈育19號增產476kg (7.5%)，臺中秈 3 號只增產 104kg (1.8%)，而臺中在來 1 號反而減產 (—0.5%)。本試驗結果顯示穗重型的品種，增施氮肥的效果較大。此結果與 Tanaka et al [19] 之報告「穗重型的品種對氮肥的反應較佳」相同，而與藍等 [11] 之報告「穗數型品種密植增肥效果較大」不同，其差異可能係由於供試品種及肥料用量不同所造成的。Baba [12] 指出在一定範圍

Table 6. Analysis of variance for yield and yield compoennts of rice variety Tainung Sen waxy 2.

Source of variation	D. F.	M. S.				
		Grain yield	Panicle No.	SpikeletNo.	Grain wgt.	Seed-set
Block	1	0.2476	52.083	1,081.757	22.101	111.499
Nitrogen levels (N)	1	3.0942	24.083	17.256	6.528	56.985
Error (A)	1	0.0623	1.333	1.429	1.677	156.286
Plant spacing (D)	3	0.0405	34.931	148.360	6.212	32.572
N×D	3	0.4431	29.931	136.476	2.712	117.275**
Error (B)	6	0.1525	8.903	522.862	2.508	9.762
Seedlings/hill (P)	2	0.9388**	27.016**	2,656.157**	3.386	12.777
N×P	2	0.0557	7.224	113.376	1.994	1.923
D×P	6	0.1024	6.655	475.088	2.234	38.730
N×D×P	6	0.0302	1.863	106.143	0.529	19.976
Error (C)	16	0.1276	4.120	302.760	1.230	23.595

* Significantly at 5% level.

** Significantly at 1% level.

內穗數型的品種對氮肥的反應，較穗重型的好。Chang [16] 之試驗結果指出，從低肥量到中肥量之肥效以穗數型較佳，而從中肥料量到重肥量的肥效則以穗重型品種爲優。兩類型的水稻對不同程度的氮肥用量，呈現不同反應，是因爲氮肥促進分蘖，致使穗數型的品種在重肥區因分蘖過多，而受遮陰的嚴重影響。

綜合本試驗及前人硏究結果，得悉水稻各品種，分別有其最適宜的生育條件，在合適的栽培管理下，才能發揮其生產潛力。依據本試驗結果，臺農秈育19號之穗重顯著地比臺中秈 3 號及臺中在來 1 號兩品種爲重，而其穗數雖顯著地少於臺中在來 1 號，却與臺中秈 3 號近似，以致產量高於臺中秈 3 號及臺中在來 1 號。就本試驗之結果，臺農秈育19號之適宜的栽培條件，應爲每欉 5 本植，然後施用重肥（氮肥）。唯進一步分析臺農秈育19號的結果指出，當臺農秈育19號以重肥栽培時，每欉 3 本植的產量高於 5 本植（圖 6）。同時在行株距 25×16cm 之密植栽培下，亦以每欉 3 本植爲佳。因此臺農秈育19號之最適栽培條件應該是每欉 5 本植，施用普通的氮肥量，或行株距 25×16cm，每欉 3 本植配合重肥。

臺農秈糯 2 號之穗數在 4 個參試品種中最少，穗重最重，亦屬於穗重型的品種，在重肥區的平均產量比普肥區增產8.1%。行株距28×16cm之產量比其他處理平均增產 100～150kg/ha，每欉 5 本植之稻穀產量平均爲6,718kg/ha，分別比 3 本植及單本植增產 3.2%及7.7%。且就臺農秈糯 2 號進行個別分析時，各處理之交感效應都不顯著，因此臺農秈糯 2 號之適宜的栽培條件應該是每欉 5 ～ 6 本植，行株距28×16cm（即一般機插密度），並施用比一般秈稻之氮肥要素量（一期作 110～160kg/ha，二期作80～140kg/ha） 約多 25%的重肥管理，如此臺農秈糯 2 號可發揮其生產潛力，得到較高的稻穀產量。

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Effects of Nitrogen Levels, Planting Spacings and Seedlings per Hill on the Grain Yield of Rice Varieties.[1]

T. H. Tseng[2]

Summary

The responses of four rice varieties, i. e., Tainung Sen waxy 2 (TNGSW 2), Tainung Sen Yuh 19 (TNGSY 19), Taichung Sen 3 (TCS 3) and Taichung Native 1 (TN 1), to two levels of nitrogen, four planting spacings and three numbers of seedlings per hill were studied in the first crop of 1984 atTaiwan Agricultural Research Institute.

The grain yield was significantly affected by varieties, planting spacings and seedlings per hill and also by the interactions between nitrogen levels and planting spacings, between nitrogen levels and varieties and between varieties and seedlings per hill. The panicles per hill increased with the increase of nitrogen and seedlings per hill. Varieties TNGSW 2 and TNGSY 19 had a smaller number of panicles per hill than TCS 3 and TN 1. The effects of different varieties and different seedlings per hill on the panicle length, panicle weight and spikelet number per panicle were all significant at 1% level. The seed-set percentage and 1,000-grain-weight were also affected by different varieties, but no significant correlation was found between each of the abovementioned growing conditions and seed-set percentage, as well as 1,000-grain weight.

The correlation coefficients between seed-set percentage and grains yield, 1,000-grain weight and grain yield were significantly positive. The panicles per hill and panicle length, panicles per hill and Panicle weight, panicles per hill and spikelets per panicle, panicles per hill and 1000-grain weight, panicles per hill and seed-set percentage, seed-set percentage and panicle length were negatively correlated. The spikelets per panicle and panicle length, panicle weight and spikelets per panicle, 1,000-grain weight and spikelets per panicle, seed-set percentage and panicle weight were positively correlated.

The grain yield of rice variety TNGSW 2 was higher at the heavy nitrogen level and a planting spacing of 28×16cm and 5-6 seedlings per hill. The grain yield of rice variety TNGSY 19 was higher at the heavy nitrogen level, 25×16 cm planting and 3 seedlings per hill.

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米粒蛋白質與顆粒澱粉含量之變異[1]

郭益全　劉　清　王強生

摘要　為探討完整無白堊質、完整有白堊質及碎米等三類型白米之蛋白質與顆粒澱粉含量之變異，本研究以 Micro-kjeldahl 定氮法及 Juliano 顆粒澱粉含量簡化定量法，分別測定栽培於宜蘭三星鄉、臺中萬豐及屏東市等三地點之臺農67號與臺南５號等兩個粳稻品種之上述三類型白米之蛋白質與顆粒澱粉含量。所得數據轉換及綜合分析後獲知，完整無白堊質、完整有白堊質及碎米等三類型白米間之米粒蛋白質與顆粒澱粉含量的差異均不顯著。而品種間及栽培地點間米粒蛋白質及顆粒澱粉含量之差異則均顯著。就品種言，臺農67號米粒蛋白質含量之三地點平均高於臺南５號者；但米粒之顆粒澱粉含量則臺南５號者高於臺農67號者。就地點言，米粒蛋白質含量最高之米粒樣品為產自屏東者，產自三星者居次，產自萬豐者最低。顆粒澱粉含量方面則產自屏東市者最高，萬豐者次之，三星者最低。

蛋白質與顆粒澱粉是關係稻米品質的兩個重要之米粒內含成份。米粒中蛋白質與顆粒澱粉含量之高低雖為品種特性之一，但却深受環境之影響[1,5,10,13]。

在水分含量為12％下，糙米蛋白質含量之品種間變域介於５—17％之間[5,9,13]。而氮肥用量與施用時期、農用化學藥劑之類別與施用、栽培地點、季節年代日照、水分管理、栽培密度及收穫時期等皆為顯著影響米粒蛋白質含量變化的較已知的大環境（macro-environment）因子[1,5]。至於微環境（micro-environment）方面之研究則 Juliano[9] 首先指出，同一試區內稻品種 IR-8 之糙米蛋白質含量因植株之不同而異；同植株內又因分蘗之不同而異；同一穗內復因小枝梗之互異而不同；且米粒蛋白質含量之變異亦隨氮肥用量之增加而增大。但 Mikaelsen and Kartoprawiro[16] 則報告在 20×20cm 行株距，單本植情況下，糙米之蛋白質含量雖亦因植株之不同而有異，但株內穗間之差異並不顯著。而謝[2] 及 Hsieh and Brunner[6] 則提出，試區間及試區內株間之糙米蛋白質含量之差異雖顯著，但同株內發育良好之五穗間及同穗內上、中及下等三部位間之米粒蛋白質含量之差異則不顯著。

白米顆粒澱粉含量之品種間變域介７—34％之間（水分含量０％）[9,10]。同品種米粒顆粒澱粉含量之環境變域以 IR-8 為例可達６％（27—33％）[11]。環境雖影響米粒之顆粒澱粉含量，但方式未明[7]。稻穀成熟期間外界之氣溫被認為是影響米粒顆粒澱粉含量之主要因素。平均氣溫升高，則米粒之顆粒澱粉含量降低，但秈稉兩型之反應並不一致[3,5,17]。氮肥之增施會導致米粒顆粒澱粉含量之略略低降，但施用時期之不同則無影響[5]。而 Gomez[5] 引述 Paule 之數據則指出米粒顆粒澱粉之株間變異遠小於株內穗間之變異。

總上可知目前有關米粒蛋白質和顆粒澱粉含量變異研究之梗概，而本研究之主要目的則在探討稻穀經去殼碾白後，依米粒之完整與否及白堊（chalkiness）之有無所歸類成完整無白堊質米、完整有白堊質米及碎米等三類型白米間米粒蛋白質及顆粒澱粉含量之變異，至於栽培地點間及品種間米粒蛋

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白質及顆粒澱粉含量之變異亦一併考慮。

材料與方法

以臺農67號及臺南5號等兩個粳型稻品種參試，分別於桃園區農業改良場宜蘭三星分場、省農業試驗所萬豐農場及高雄區農業改良場屏東市本場等三地點栽培。5行區，每行20株，行株距 22.5×22.5cm。每試區兩品種併對排列，兩重覆。1984年一期作。肥料用量 N、P_2O_5 及 K_2O 分別爲三星分場105、51及96kg/ha；萬豐本所90、40及60kg/ha；屏東本場120、54及 60kg/ha。肥料施用及栽培管理悉由各場所按當地慣行方式進行。適期收穫及初步調製乾燥後，各樣品統籌由本所以日製 Satake 去殼機去殼後，再以美製 McGill miller No. 2 碾米機碾成白米。所得各該白米樣品以人工依米粒之完整與否分成完整白米及碎米，各該完整白米再依白堊之有無歸類成完整無白堊質米與完整有白堊質米等兩類。此三類型白米以 Udy 旋風式磨粉機 (cyclone mill) 磨成米粉。60°C，烘乾24小時。以 Micro-Kjeldahl 測定各米粉樣品之 Kjeldahl-N，再由 Kjeldahl-N×5.95計算各樣品之蛋白質含量，顆粒澱粉含量則仿 Juliano[8] 之簡化法定量之。因米粒之蛋白質與顆粒澱粉含量數據係屬百分率，故在資料行綜合分析前曾加以 Sin^{-1} 轉換。

結　　果

一、參試材料白米蛋白質及顆粒澱粉含量變異之綜合分析：

爲初步明瞭兩水稻品種在三栽培地點的完整無白堊質、完整有白堊質及碎米等三類型白米間米粒蛋白質及顆粒澱粉含量之變異乃將所得資料進行綜合分析，分析結果列於表1。由表1知，供試水稻材料白米之蛋白質及顆粒澱粉的含量在完整無白堊質米、完整有白堊質米及碎米等三類型白米間之差異並不顯著，但在三栽培地點及兩品種間則有差異存在，其在統計上之意義分別爲蛋白質含量方面均達5%之顯著水準，顆粒澱粉含量方面均達1%之極顯著水準。至於交感作用方面，白米蛋白質含量之地點與品種、地點與白米類型、品種與白米類型及地點與品種與白米類型間之交感作用俱不存在。而顆粒澱粉含量之地點與品種及地點與品種與白米類型間則有交感作用存在，餘地點與白米類型及品種與白米類型間之交感作用則不顯著。

表 1. 白米蛋白質與顆粒澱粉含量之變方分析

Table 1. Analyses of variance for protein and amylose contents of milled-rice.

Source of variance	D. F.	Protein content	Amylose content
Location (L)	2	*	**
Variety (V)	1	*	**
L X V	2	ns	ns
Milled-rice of grain type (C)	2	ns	ns
L X C	4	ns	ns
V X C	2	ns	ns
L X V X C	4	ns	*

ns: No siginificant;
* : Significant at 5% level;
**: Significant at 1% level.

表 2. 白米蛋白質與顆粒澱粉含量之地點與品種變異

Table 2. Variability of protein and amylose contents of milled-rice with respect to locations and varieties.

Location	Protein content (%)			Amylose content (%)		
	Tainung No. 67	Tainan No. 5	Mean	Tainung No. 67	Tainan No. 5	Mean
San Hsing	7.03	7.04	7.04	18.77	19.83	19.30
Wan Feng	5.73	5.46	5.59	19.43	20.88	20.16
Ping Tung	7.67	6.57	7.12	20.50	20.62	20.56
Mean	6.81	6.35	6.58	19.57	20.44	20.01
LSD 0.05	—	—	1.02	—	—	0.47
LSD 0.01	—	—	1.87	—	—	0.86

二、兩品種在三栽培地點白米蛋白質和顆粒澱粉含量之變異：

已知白米之蛋白質與顆粒澱粉含量有品種間及栽培地點之差異存在（表 1），茲進一步將兩品種在三地點白米蛋白質及顆粒澱粉含量之變異列如表 2。由表 2 就兩供試品種在北、中及南等三地點的綜合表現言，臺農67號白米蛋白質含量之三地點平均高於臺南 5 號之三地點平均，但臺南 5 號白米顆粒澱粉含量之三地點平均則高於臺農67號者。就三栽培地點供試兩水稻品種白米蛋白質及顆粒澱粉含量之變異言，產自屏東市之白米有最高之蛋白質及顆粒澱粉含量，產自萬豐之白米有最低之蛋白質含量及次高之顆粒澱粉含量，產自三星試區之白米有次高之蛋白質含量與最低之顆粒澱粉含量。亦即白米蛋白質與顆粒澱粉含量因栽培地點不同之試區變異趨勢並不一致，此種不甚規則之試區變異以兩品種分別考慮時更爲明顯。

三、兩品種三類型白米蛋白質與顆粒澱粉含量之變異：

臺農67號完整無白堊質米及完整有白堊質米之蛋白質及顆粒澱粉含量似皆有具較碎米者略高之傾向，但差異極微（表 3）。就臺南 5 號而言，本品種雖亦存有完整白米之蛋白質含量略高於碎米者之傾向，但完整白米之顆粒澱粉含量却無高於碎米者之傾向。綜覽兩品種三類型白米蛋白質及顆粒澱粉含量之變異可知，臺農67號之完整無白堊質白米有較高之蛋白質含量；完整有白堊質米則有較高之顆粒澱粉含量。臺南 5 號則以完整有白堊質米有較高之蛋白質及顆粒澱粉含量。亦即三類型白米蛋白質及顆粒澱粉含之變異趨勢不僅有品種間之差異，亦因目標性狀之不同而不同。

表 3. 白米蛋白質與顆粒澱粉含量之品種與白米類型之變異

Table 3. Variability of protein and amylose contents of milled-rice with respect to varieties and milled-rice grain types.

Variety	Protein content (%)			Amylose content (%)		
	Head rice		Broken rice	Head rice		Broken rice
	Chalkiness-free grain	Chalky grain		Chalkiness-free grain	Chalky grain	
Tainung No. 67	6.87	6.82	6.73	19.55	19.62	19.53
Tainan No. 5	6.37	6.49	6.21	20.20	20.72	20.42

表 4. 白米蛋白質與顆粒澱粉含量之地點與白米類型之變異

Table 4. Variability of protein and amylose contents of milled-rice with respect to locations and milled-rice grain types.

Location	Protein content (%)			Amylose content (%)		
	Head rice		Broken rice	Head rice		Broken rice
	Chalkiness-free grain	Chalky grain		Chalkiness-free grain	Chalky grain	
San Hsing	7.01	7.23	6.88	19.20	19.58	19.13
Wan Feng	5.66	5.73	5.49	20.00	20.30	20.23
Ping Tung	7.29	7.01	7.05	20.48	20.63	20.58
Mean	6.62	6.66	6.47	19.88	20.17	19.98

四、三地點三類型白米蛋白質及顆粒澱粉含量之變異：

綜觀產自三地點各類型白米蛋白質及顆粒澱粉含量之變異發現，三類型米粒之白米蛋白質含量的三地點平均以完整有白堊質米最高，完整無白堊質米次高，碎米最低。白米顆粒澱粉含量之三地點平均以完整有白堊質米最高，碎米次高，完整無白堊質米最低。而就栽培地點別考慮三類型米粒之白米蛋白質及顆粒澱粉含量變化時，產自北部及中部白米之蛋白質含量變異為完整有白堊質米>完整無白堊質米>碎米；產自南部者為完整無白堊質米>碎米>完整有白堊質米。至於顆粒澱粉含量之變異，北部為完整有白堊質米>完整無白堊質米>碎米；中南部一致皆為完整有白堊質米>碎米>完整無白堊質米。

討　論

蛋白質及顆粒澱粉含量為關係稻米品質之兩個最重要因子。米粒之蛋白質含量不僅左右稻米之營養品質，並為白米烹調品質之主要決定因素之一，同時亦會間接影響到食用品質與米粒外貌[7,15]。而白米之顆粒澱粉含量則是被認為決定秈米食用品質之最主要的因素[7,9,10,12]，為秈米主食國家育種計畫中最受考慮之化學性狀。但因為稻米之蛋白質與顆粒澱粉含量雖為品種特性之一，却受環境因子強烈之影響[1,5,10,13]。因之，針對此兩化學性狀取樣代表性育種基礎資料之變異研究乃為有關米粒蛋白質與顆粒澱粉含量變異研究中之一個較偏重實用性的研究重點[2,5,6,14,16]。其他諸如日照、氣溫、水分、氮肥用量及施用期等環境因子與米粒內含成分變異之研究則屬較理論性地米粒蛋白質含量變異之探討[1,3,11,17]。而本研究則以稻米品質研究之觀點來探討完整無白堊質米，完整有白堊質米及碎米等三類型白米蛋白質及顆粒澱粉含量之變異，其意義上自又與上述前人之研究不同[1,2,5,6,11,14,16,17]。

Paule（引自 Gomez[5]）鑑於白米顆粒澱粉含量之株間變異遠小於株內穗間之變異，因而推荐顆粒澱粉含量之測定以混合樣品（bulk sample）行之。而 Juliano[14] 之研究雖指出米粒之蛋白質含量雖同試區內有株間、株內穗間及穗內部位間之差異且其變異隨氮肥用量之增加而增加，但 Juliano 氏亦曾就其研究結果建議，就叢（hill）言，叢總稻穀中逢機10個稻穀行蛋白質測定已具叢代表性；就小區言，逢機取自小區混合樣品之稻穀亦具小區代表性。本研究中樣品之獲得是每小區去頭尾及邊行後以小區為單位之混合樣品。每小區混合樣品中又逢機取出 150g 之稻穀樣品兩個，此每 150g 為單位樣品經分別去穀碾白分類後，再分別磨粉及蛋白質與顆粒澱粉含量之定量。蛋白質含量之定量每單位樣品取約 200mg（約合白米10—12粒）為受測樣品，重覆三次（即每單位樣品測三次）；顆粒澱粉含量之定量則每單位樣品皆各測二次。亦即本研究中每一小區白米之蛋白質含量為小區內分立的六個混合樣品之綜合表現；顆粒澱粉含量為小區內分立的四個混合樣品之綜合成績。同時本研究中每

品種每地點重覆兩次，因之研究中每品種每地點每類型米蛋白質含量之數據是爲每品種分立的十二個混合樣品之綜合表現；顆粒澱粉含量是爲分立的八個混合樣品之平均。故認爲本研究中每試區或每地點或每品種或每類型米之蛋白質及顆粒澱粉含量已具代表性，據而所作之推定，前提應無問題。

研究結果顯示品種間及栽培地點間白米之蛋白質含量及顆粒澱粉含量皆顯著，此和前人[1,5,11]之報告相符。但檢討三栽培地點之曾記載的重要環境因子時，氮肥之用量屏東、宜蘭、萬豐分別爲 120、105、90kg/ha；穀粒成熟期間月平均氣溫三星（27.5°C）＞萬豐＞屏東，各差約 1°C 左右；月累積日照時數三星214小時，萬豐146小時，屏東113小時；月平均雨量萬豐 374mm，屏東 272mm，三星 123mm。本研究數據顯示兩品種三地點蛋白質含量之變異爲屏東＞三星＞萬豐；顆粒澱粉含量爲屏東＞萬豐＞三星。前人研究指出增施氮肥可增加米粒蛋白質含量及導致顆粒澱粉含量之略略低減[5]；穀粒成熟期間氣溫之升高可使日本型水稻之蛋白質含量大大增加，而顆粒澱粉含量則降低[3,5,17]；稻穀成熟期間之高日照量（high solar radiation）蛋白質含量因之低降[5]。援前人之研究配合研究中曾加以記錄之若干環境因子來分別考慮本研究之數據時，本研究之結果有與前人一致者，有未符合者。然大體而言，蛋白質含量之栽培地點變異雖兩品種之表現不一，但大致上與各地點的氮肥用量一致（未考慮各地之土壤肥力）。即增施氮肥有較高之蛋白質含量。顆粒澱粉含量之栽培地點變異亦與各地穀粒成熟期之氣溫有關，兩品種雖亦不太一致，但平均而言仍隨氣溫之升高而降低。

完整無白堊質米，完整有白堊質米及碎米等三類型白米之蛋白質含量與顆粒澱粉含量之差異不顯著（表 1）。前人組織解剖指出米粒白堊部分爲米粒胚乳中澱粉顆粒及蛋白質體堆積較不緊密而含有空氣，且其澱粉顆粒異於正常透明部分之多角形（polygon）而呈圓型（round）[14,18]。因之似可推定，稻米白堊質之出現雖更易於糙米碾成白米時碎裂，而間接影響稻米之市場品質[7,15] 但在本研究僅以完整無白堊質米、完整有白堊質米及碎米等三類型白之分類前提下，並不能肯定米粒白堊質之有無是否眞與米粒中之蛋白質與顆粒澱粉之含量無關，雖然含白堊質之完整有白堊質米及碎米之白米顆粒澱粉含量似有較無白堊質之完整無白堊質米略略爲高之傾向。亦即米粒白堊質部分之澱粉顆粒及蛋白質體堆積及形狀等微細構造（ultrastructure）之不同是否影響到白堊質部分之蛋白質與顆粒澱粉含量則有待進一步之研究。

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Variability of Protein and Amylose Contents of Milled-rice[1]

Y. C. Kuo, C. Liu and C. S. Wan[2]

Summary

This paper investigated the variability of protein and amylose contents among chalkiness-free head rice, chalky head rice and broken rice in two commercial *Joponica* varieties planted in three locations.

Differences in protein and amylose contents were not significant among three types of milled-rice grain. However, differences in protein and amylose contents of milled-rice were significant at 5% and 1% level, respectively, between varieties and among locations. The mean protein content of milled-rice for three locations of Tainung No. 67 was higher than that of Tainan No. 5. On the other hand, the mean amylose content of milled-rice for three locations of Tainung No. 67 was lower than that of Tainan No. 5. Protein content of milled-rice from Ping Tung was the highest, followed by from San Hsing and from Wan Feng; amylose content of milled-rice from Ping Tung was also the highest, but followed by from Wan Feng and from San Hsing.

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蠟質基因對於玉米子實容積重及砂耕幼苗生長勢之影響[1]

劉孔生[2]　　陳　成[3]

摘要　玉米蠟質基因之作用雖係改變胚乳內澱粉之組成，但亦會影響到子實之物理特性及幼苗之生長。為明瞭蠟質基因之效應，本試驗乃以不同組合之非蠟質與蠟質子實測定其含水量及容積重。結果顯示非蠟質子實含水量較多，且其差異受親本遺傳背景所影響。如進行吸濕處理，非蠟質子實較易吸收水分，進行乾燥處理則以蠟質子實較易失去水分。至於兩種子實之容積重，經吸濕處理時無顯著差異，但乾燥處理後則以非蠟質子實之容積重較重。

再將非蠟質與蠟質種子發芽、進行砂耕，經駢對 t 值測驗後得知非蠟質幼苗較重。但此係由於非蠟質子實較重而影響試驗結果，以子實重加權後差異即不顯著。再比較親本之影響，發現由不同親本所獲得之幼苗，其生長勢具有極顯著的差異。故幼苗生長勢主要受親本之遺傳背景所影響，蠟質基因之作用不大。

根據 Wetherwax[17] 的研究報告，蠟質玉米（waxy corn）係由 G. N. Collins 於1909年自中國玉米中發現，由於其具有類似於硬蠟質地的蛋白質，因此稱之為蠟質玉米[5]。蠟質基因為孟德爾（Mendel）式之單一基因（single gene）遺傳，非蠟質基因（non-waxy gene）對蠟質基因為完全顯性（complete dominance）[6]。其主要作用係改變胚乳內澱粉之組成[10]，蠟質胚乳完全由膠澱粉（amylopectin）組成，普通玉米則含有75%的膠澱粉及25%的顆粒澱粉（amylose）[12]。因此將胚乳切開以碘液染色後，蠟質者呈紫紅色，而一般玉米則呈藍黑色[9]（請參閱圖1）。蠟質基因極為穩定不易發生突變，且具有花粉直感效應（xenia effect），在花粉及當代種實即可表現[8,13]，對於玉米成株無明顯之影響，因此適合作為全套染色體轉座系統（whole set of chromosomal translocation stocks）之標識基因（marker gene）[1]。然而由於蠟質基因會改變胚乳內澱粉組成之比例，因此亦可能會影響到子實之物理特性及幼苗生長勢，故本試驗乃以轉座系統為材料，來研究蠟質基因對於子實性狀之效應，以及對砂耕幼苗生長勢之影響，以明瞭蠟質基因對這些性狀之作用，作為將來遺傳研究及育種實施之參考。

材料與方法

本試驗利用引進之蠟質全套染色體轉座系統（其系統名稱、代號及細胞學資料見表1）及正常染色體之非蠟質自交系 H95（基因型為 WxWx）為材料，於民國70年春季進行全套轉座系統與 H95 自交系間之交配，以收穫九組 F_1 種子（基因型為 Wx wx，以 Ti×H95 代表；i=1, 2, …, 9）。

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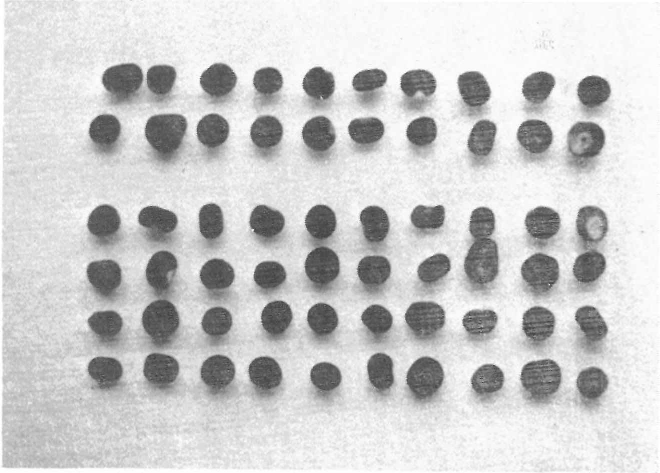

圖 1：玉米非蠟質與蠟質胚乳之碘液檢定。

Fig. 1. Iodine solution test of non-waxy and waxy endosperm of corn.

最上排：非蠟質胚乳（藍黑色）。

Top row: Non-waxy endosperm (dark-blue).

第二排：蠟質胚乳（紫紅色）。

Second row: Waxy endosperm (purple-red).

第三至第六排：分離之 F_2 世代非蠟質與蠟質胚乳之分離比。

Third to sixth rows: Segregation of non-waxy and waxy endosperms in F_2 generation.

表1. 玉米第九對染色體全套相互轉座系統之名稱、代號及細胞學資料

Table 1. Name, code number and cytological information in whole set of chromosomal reciprocal translocation stocks.

轉座系統名稱 Name of translocation stock	代號 Code No.	相互轉座染色體對 Reciprocal translocation chromosome	斷點位置 Position of break point		標識基因 Marker gene
$1-9_{4995}$	T_1	1—9`	1L 0.19	9S 0.20	wx/wx
2—9b	T_2	2—9	2S 0.18	9L 0.22	wx/wx
3—9c	T_3	3—9	3L 0.09	9L 0.12	wx/wx
4—9g	T_4	4—9	4S 0.27	9L 0.27	wx/wx
5—9a	T_5	5—9	5L 0.69	9S 0.17	wx/wx
6—9b	T_6	6—9	6L 0.10	9S 0.37	wx/wx
7—9b	T_7	7—9	7S 0.76	9S 0.19	wx/wx
8—9d	T_8	8—9	8L 0.09	9S 0.16	wx/wx
9—10b	T_9	10—9	10S 0.40	9S 0.13	wx/wx

再於70年秋季種植九組 F_1 及全套轉座系統，進行 Ti×(Ti×H95) 之回交，以產生九組回交種子。今以 $1-9_{4995}$系統一組爲例，說明回交之過程：

親　　本	$1—9_{4995}$	×	H95
胚基因型：	蠟質 wx wx		非蠟質 Wx Wx
胚乳基因型：	蠟質 wx wx wx		非蠟質 Wx Wx Wx
		↓	
	$1—9_{4995}$	×	F_1
胚基因型：	蠟質 wx wx		非蠟質 Wx wx
胚乳基因型：	蠟質 wx wx wx		非蠟質 Wx wx wx
		↓BC	
	蠟質種子		非蠟質種子
胚基因型：	蠟質 wx wx		非蠟質 Wx wx
胚乳基因型：	蠟質 wx wx wx		非蠟質 Wx wx wx

於果穗成熟後每組合收取二果穗，置於具有吹風裝置之烘箱內以 40°C 加熱烘乾以除去水分。而後將果穗脫粒，各組合分別依照子實外觀區分為蠟質與非蠟質二類（蠟質子實呈粉狀不透明，非蠟質子實則呈半透明且反光），再於蠟質與非蠟質種子中逢機各選取 100粒，以紙袋盛裝，於 25°C 及60%相對濕度之環境下放置七天，使子實與外界之水分達於平衡，秤其重量（百粒重）後進行下列處理。

九組回交組合之蠟質與非蠟質子實每組各取一組合種子，置於乾燥皿（desiccator）內，再於底部加入少許蒸餾水，使乾燥皿內之相對濕度維持 100%，而玉米不至於與水直接接觸，以凡士林密封皿蓋後置於 30°C 進行回潮（吸濕處理）。各組合的另一果穗子實亦置於乾燥皿內，但底部加入矽膠（silica gel）作為乾燥劑，置於 4°C 進行脫水（矽膠乾燥處理）。處理一週後將各組合取出，迅速秤其百粒重。再取 50ml 量筒，加入 20ml 水及處理後之玉米子實，由量筒之刻度扣除 20ml 求得百粒種子之體積。測定後之種子再置於烘箱之內，依 Andrew *et al.*[3] 之方法以 80°C 加熱48小時，除去水分後秤其百粒重。獲得的結果依照下列公式，計算各種導出性狀。

$$\text{原始含水量（未處理）}=\frac{\text{25°C, 60\%相對濕度之百粒重}-\text{80°C, 48小時後之百粒重}}{\text{25°C, 60\%相對濕度之百粒重}}\times 100$$

$$\text{吸濕處理增加之含水量}=\frac{\text{吸濕後之百粒重}-\text{25°C, 60\%相對濕度之百粒重}}{\text{25°C, 60\%相對濕度之百粒重}}\times 100$$

$$\text{乾燥處理減少之含水量}=\frac{\text{25°C, 60\%相對濕度之百粒重}-\text{矽膠乾燥後之百粒重}}{\text{25°C, 60\%相對濕度之百粒重}}\times 100$$

$$\text{吸濕處理後之容積重}=\frac{\text{吸濕後之子實重 (g)}}{\text{吸濕後之體積 (ml)}}$$

$$\text{乾燥處理後之容積重}=\frac{\text{矽膠乾燥後之子實重 (g)}}{\text{矽膠乾燥後之體積 (ml)}}$$

再將各種性狀進行 t 值顯著性測驗，以探討含水量與容積重之變化。

測定蠟質與非蠟質玉米幼苗生長勢所使用的材料，亦為70年秋季所收穫之九組回交種子。將各組回交種子依外表型區分為蠟質與非蠟質後，各逢機選取30粒，分別秤其重量並換算成百粒重與平均種子重。再以1／1000之烏斯普龍（suplum）溶液消毒三小時，經清水洗淨後浸種12小時，於 30°C 催芽，經三日後再計算發芽率。同時每組合逢機取10粒發芽種子，依照 Bennet *et al.*[4] 之方法進行砂耕。行距五公分株距四公分，生長期間僅澆以清水不施任何養分。30天後（第三葉片完全展開）割取地上部（見圖2）稱量鮮重，再置於 80°C 之烘箱內加熱48小時，除去水分後稱量乾重，以鮮重與乾重作為幼苗生長勢之指標[15]。

將資料進行親本系統與蠟質基因之二重複因子變方分析，以明瞭親本系統與蠟質基因對幼苗生長

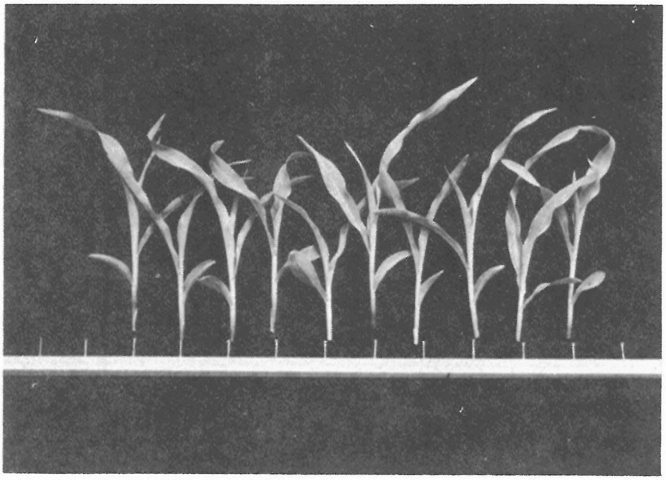

圖2. 割取之砂耕玉米幼苗地上部

Fig. 2. The upper part of corn seedlings in sandy-culture.

勢之效應。再利用騈對 t 值測驗（paired t-test），比較非蠟質與蠟質幼苗生長勢之差異，以探討蠟質基因對幼苗生長勢之影響。

結果與討論

由回交分別獲得之蠟質與非蠟質之同果穗子實經吸濕與乾燥處理後，所得之各項資料以騈對 t 值進行顯著性測驗，測驗結果列於表 2。在未處理前，非蠟質與蠟質子實之百粒重具有顯著的差異，且非蠟質子實之百粒重較重，此點與 Creech 及 McArdle[7] 之結果相同。經過處理後二者仍有顯著的差異，故不論吸濕或乾燥處理，非蠟質子實仍較蠟質子實為重。再比較子實的含水量，在處理之前非蠟質子實的含水量均較高，且達極顯著水準，顯示在 25°C 及60%相對濕度的環境下，兩種子實所含水分並不相同，因此胚乳中顆粒澱粉與膠澱粉之比例會影響子實含水量。Nass and Crane[14] 亦

表2. 非蠟質與蠟質玉米子實經吸濕或乾燥處理之百粒重、含水量與容積重之 t 值顯著性測驗

Table 2. The t-test of 100-seed weight, water content and bulk density of non-waxy and waxy kernels by wet or dry treatment in corn.

處理 Treatment			百粒重 100-seed wt.		含水量 Water content[a]		處理後之容積重 Bulk density after treatment
			處理前 Untreated	處理後 Treaed	處理前 Untreated	處理後 Treated	
吸濕 Wet	平均 Mean	非蠟質Non-waxy	24.89g	25.87g	9.33%	13.63%	1.17g/ml
		蠟質Waxy	23.69g	24.58g	8.69%	12.78%	1.19g/ml
	差異 Difference	t 值測驗 t-test	*	*	**	**	ns
乾燥 Dry	平均 Mean	非蠟質Non-waxy	25.14g	22.70g	10.27%	8.30%	1.20g/ml
		蠟質Waxy	24.51g	23.01g	9.70%	2.91%	1.16g/ml
	差異 Difference	t 值測驗 t-test	*	*	**	**	*

a 水分含量係指以 80°C 加熱48小時後所剩餘之重量為標準，所失去的水分所佔之百分比，而非絕對含水量。

曾注意到非蠟質與蠟質胚乳之含水量，但他們的資料顯示蠟質胚乳含水量較多，與本試驗所得結果相反，推測可能由於 Nass 與 Crane[14] 係將果穗採收後立刻烘乾測定含水量，而本試驗先將果穗以 40°C 除去部分水分後再行測定。因此蠟質子實在植株上乾燥速度較慢，收獲時會含有較多的水分，但稍行乾燥後反而較易失去水分，使含水量低於非蠟質子實。所以 Brink and Abegg[5] 以經過初步乾燥的種子測定含水量，亦顯示蠟質子實含水量較低。此點對於測定百粒重亦很重要，由於一般均以烘乾後的種子測定百粒重，此時蠟質子實含水量較少，測得百粒重較輕，可能產生誤差。經過吸濕處理後，非蠟質與蠟質子實之含水量均增加，但二者之間仍有極顯著的差異，顯示非蠟質子實在高濕度的環境下仍可吸收相當多的水分，而蠟質子實吸收水分後含水量仍較少。在乾燥處理方面，蠟質子實會失去大部分水分，非蠟質則較不易乾燥，因此處理後二者之間具有極顯著的差異，由此再度顯示在收獲後蠟質子實較易乾燥。再比較處理後的容積重，吸濕處理後兩種子實容積重之差異不顯著，因此兩種子實吸水後具有相同的比重。但乾燥處理後，非蠟質子實的容積重較蠟質者為重，且達於顯著水準，因此非蠟質子實組織緊密，蠟質則較鬆散，此點亦可能促使蠟質子實於收穫後較易乾燥。

為比較蠟質基因對於幼苗生長勢的影響，試驗中亦將非蠟質與蠟質種子發芽，進行砂耕來比較其幼苗生長勢。由於種子的大小直接影響貯存養分之多寡，因而影響到幼苗之發芽及初期生育[11]。故在分析蠟質基因效應前，先測驗使用材料之發芽率、百粒重、鮮重與乾重間之相關，其測驗結果列於表 3。其中鮮重、乾重與百粒重均呈顯著之正相關，鮮重與乾重更高達 0.989，顯示在所有的參試組合幼苗含水量差異不大，鮮重與乾重均可作為生長勢之指標。又由於百粒重與幼苗重呈正相關，為避免由種子大小所造成的誤差，除利用原始資料進行分析外，尚利用種子重進行加權，由獲得的指數作為加權資料，同時進行分析。

指數＝幼苗重量／種子重量

表3. 不同親本系統、蠟質基因組合之回交世代玉米幼苗之百粒重、發芽率、鮮重與乾重之相關顯著性測驗[a]

Table 3. The correlations among 100-seed weight, germination rate, fresh weight and dry weight of different genetic combinations in back crossing generation of corn seedling.[a]

相關 Correlation	百粒重 100-seed wt.	發芽率 Germination rate	鮮重 Dry wt.	乾重 Fresh wt.
百粒重 100-seed wt.	—			
發芽率 Germination rate	−0.191ns	—		
乾重 Fresh wt.	0.739**	−0.582**	—	
鮮重 Dry wt.	0.795**	−0.221ns	0.989**	—

a 重複次數：18。

非蠟質與蠟質幼苗之複因子變方分析列於表 4，其中親本系統之效應，不論鮮重、乾重，原始或加權資料均達於極顯著，顯示幼苗生長勢深受親本遺傳背景之影響。蠟質基因之效應在原始資料的鮮重達於極顯著水準，於乾重為顯著，但經加權後蠟質基因的效應成為顯著及不顯著。主要由於非蠟質子實較重，因此原始資料中非蠟質與蠟質幼苗間具有顯著的差異，但經加權後差異即減小。至於鮮重與乾重之結果略有差異，則係因非蠟質幼苗含水量較多使鮮重較重。因此嚴格的說來應採用加權資料

中的乾重爲準，亦即蠟質基因對幼苗生長勢無影響，生長勢主要由親本系統控制，而交感效應雖均達極顯著，主要係由親本遺傳背景所造成。

表4. 玉米親本系統與蠟質基因對回交世代砂耕幼苗生長勢之複因子變方分析

Table 4. The ANOVA of corn seedling vigour by factorial (parental genetic background and waxy gene) design in back crossing generation.

變因 S. V.	自由度 df	均方 MS			
		原始資料 Original data		加權資料 Weighted data	
		鮮重 Fresh wt.	乾重 Dry wt.	鮮重 Fresh wt.	乾重 Dry wt.
親本系統 Parental stock (P)	8	1.1597**	0.0159**	22.3305**	0.1911**
蠟質基因 Waxy gene (W)	1	0.3184**	0.0019 *	5.8471 *	0.0332ns
交感效應 Interaction (P×W)	8	0.2436**	0.0024**	6.7665**	0.7577**
機差 Error	162	0.0256	0.0003	0.9139	0.0106

表5爲各組回交組合非蠟質與蠟質幼苗之 t 值顯著性測驗，其中回交親本爲$1—9_{4995}$, $3—9_c$, $4—9_g$, $5—9_a$ 之四組幼苗，其非蠟質幼苗均較重且達極顯著水準。$7—9_b$ 與 $9—10_b$ 則蠟質幼苗顯著的較重。$2—9_b$ 之回交組合蠟質幼苗雖較重，但未達顯著水準，不能視爲有差異。至於 $6—9_b$ 及 $8—9_d$

表5. 玉米蠟質基因對九組回交組合砂耕幼苗生長勢平均值之 t 值顯著性測驗

Table 5. The t-test between non-waxy and waxy gene of corn seedling vigour in nine back crossing combinations.

回交親本 Parent of back cross		鮮重 Fresh wt.			乾重 Dry wt.		
		非蠟質 Non-waxy	蠟質 Waxy	t 值測驗 t-test	非蠟質 Non-waxy	蠟質 Waxy	t 值測驗 t-test
原始資料[a] Original data[a]	$1—9_{4995}$	1.3190	0.8290	+, **	0.1354	0.0930	+, **
	2—9b	0.6110	0.6290	−, ns	0.0623	0.0651	−, ns
	3—9c	0.9590	0.6970	+, **	0.1018	0.0691	+, **
	4—9g	1.4320	1.2320	+, **	0.1591	0.1434	+, **
	5—9a	0.6850	0.5010	+, **	0.0746	0.0598	+, **
	6—9b	0.9330	0.9660	−, ns	0.0998	0.1036	−, ns
	7—9b	1.0580	1.1080	−, **	0.1147	0.1180	−, *
	8—9d	0.9920	1.0120	−, ns	0.1052	0.1113	−, *
	9—10b	0.9980	1.2560	−, **	0.1118	0.1427	−, **
	總和Total	0.9986	0.9144	+, **	0.1072	0.1007	+, **

續表5.

回交親本 Parent of back cross		鮮重 Fresh wt. 非蠟質 Non-waxy	蠟質 Waxy	t 值測驗 t-test	乾重 Dry wt. 非蠟質 Non-waxy	蠟質	t 值測驗 t-test
加權資料 [b] Weighted data[b]	$1—9_{4995}$	6.6182	4.3863	+, **	0.6793	0.4918	+, **
	2—9b	5.5000	6.7129	—, ns	0.6630	0.6946	—, ns
	3—9c	8.3902	6.6381	+, **	0.8905	0.6579	+, **
	4—9g	6.4709	5.7116	+, **	0.7189	0.6647	+, **
	5—9a	4.7141	3.5786	+, **	0.5137	0.4273	+, **
	6—9b	5.5868	6.5403	—, **	0.5974	0.7011	—, **
	7—9b	5.9539	6.2493	—, **	0.6452	0.6654	—, **
	8—9d	5.6236	5.7928	—, ns	0.5962	0.6369	—, *
	9—10b	3.7846	4.7884	—, **	0.4240	0.5440	—, **
	總和Total	5.9603	5.5998	+, **	0.6365	0.6093	+, *

a 單位爲 g/株； *b* 幼苗單株重量與子實重之比值

兩系統則在鮮重、乾重，加權與不加權有不同之結果。$6—9_b$ 回交組合之蠟質幼苗較重，但原始資料差異不顯著，原因在於 $6—9_b$ 組合之蠟質子實較輕，雖然生長勢較强，却由於原先貯存的乾物重較低，因此無顯著差異，經加權消除百粒重之差異後，顯現出極顯著之生長勢。$8—9_d$ 之回交組合原始資料與加權資料結果一致，但鮮重與乾重不同，主要係因非蠟質幼苗含水量較多，因此蠟質幼苗之生長雖然較快，在鮮重却無顯著差異。至於總和之資料均顯示非蠟質幼苗顯著的較重，故由本試驗所使用之材料綜合上列結果，可認爲大部分非蠟質幼苗之生長勢較强。

Brink 與 Abegg [5] 曾指出蠟質胚乳在發芽時分解較快，因此蠟質幼苗本應具有較高的生長勢，而本試驗結果却指出非蠟質之生長勢較强，可能由於玉米在三葉齡時正値異營 (eutrophic) 與自營 (autotrophic) 生長交替之際，而蠟質基因使幼苗生長速率減慢，故其光合能力並未顯著的較高，反而由於消耗較多的澱粉，使得鮮重與乾重均較低。

玉米之蠟質基因雖屬於單對隱性基因，遺傳行爲遵循孟德爾定律，產生3：1之分離比，却由於蠟質胚乳內澱粉累積的速度較慢，因此使乾物重減少。此外蠟質基因不僅使幼苗重量減輕，對於成株的生育亦發生影響。 Russell 與 Eberhart [16] 比較非蠟質與蠟質植株的性狀，指出蠟質玉米的株高較低，開花提早，雄穗的分枝數減少，果穗的行數亦較少，僅穗長較長。因此蠟質基因雖僅係單一基因發生突變，對於玉米的許多性狀却都會有影響，故在早期分類時曾將蠟質玉米區分成蠟質亞種 (subspecies) [2] 。

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Effects of Waxy Gene on Kernel Bulk Density and Seedling Vigour in Maize[1]

Kong-Sheng Liu[2] and Cheng Chen[3]

Summary

Waxy gene can affect the starch composition and physical characters of corn kernels as well as seedling vigour. In this experiment non-waxy and waxy kernels derived from different cross combinations were harvested for moisture content and bulk density determinations. The results showed that: Moisture content was higher in non--waxy kernels and in somecases closely associated with parental genetic background. The rate of water absorption of non-waxy kernels was higher than that of waxy kernels under treatment in saturated moisture condition. However, the waxy kernels lost water more easily than that of non-waxy kernels under drying treatment and the bulk density of non-waxy kernels was greater compared to waxy one.

Kernels of waxy and non-waxy types were germinated and planted on sand-bed. Seedling vigours of both kernel types were tested by paired t-test. Seedling vigour was tested after dividing by kernel weight since kernel weight could affect seedling vigour. The results showed that: The seedling vigour of non-waxy and waxy types had no significant difference. However, the seedlings from various cross combinations had highly significant difference in vigours, indicating that seedling vigour was affected by genetic background rather than kernel waxiness.

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大豆不同節位之供源與積儲關係研究[1]

曹紹徽　王強生　劉大江[2]

摘要　本試驗以大豆十石品種爲材料，於生殖生長期間分析自基部計算第6、8與12（最頂端）節位葉片之葉面積與葉綠素含量，葉片及莢果乾物重、氮素與非構造性碳水化合物（TNC）濃度，以比較不同節位供源一積儲單位間之生理差異，以及對產量的影響。試驗結果顯示在種子形成（R5）期以前，各性狀並未顯示出節位性差異，亦即各供源一積儲單位間的關係較爲單純，在此一時期葉片具有較高的生理活性，比葉重與TNC濃度增高，氮素濃度未明顯下降，而莢果壁具有暫時性的積儲功能。自種子開始形成以後，由於不同節位葉片之發生時序（sequential ontogeny）導致生理活性差異，增加了供源葉片與積儲種子間關係的複雜性；頂端節位葉片的比葉重持續上升，莢果壁含有較高的乾物重與氮量，但種子產量，充實速率及種子充實度均較低，與較低節位的表現相反，亦即上位葉片雖能維持較長的生理活性，但下位莢果對產量的重要性較高。試驗結果建議如能延緩大豆葉片生理活性之老化及提高高節位莢果種子之充實度，應可改善供源與積儲間之關係，並進而提高產量。

光合作用是控制作物生長與產量的主要因子，葉片的光合潛力除了受環境因子的作用外，還受到光合產物轉運與利用效率的影響 (1)，亦即與光合產物供需平衡與否有密切的關係。作物乾物質與營養要素在各器官之間的分配受供源（source）與積儲（sink）間相互作用所支配，任何關於供源或積儲之改變均可能接直接影響同化物質及養分之分配型式 (21)；Tanaka (17) 指出這種供源與積儲間相互作用的結果可決定作物產量，欲使作物有最高產量，必須有最適當的供源與積儲配合。

在臺灣可於春、夏或秋作栽培大豆，但由於環境因子的影響，農藝性狀與產量有明顯的期作性差異 (3)。農業試驗所作物生理研究室於春、夏作在臺中地區栽培大豆，發現春作有較旺盛的營養生長，但夏作有較大的乾物質生產力且生殖生長期間乾物質分配效率較高 (1)；本研究室未發表的報告顯示，在大豆始花（Rl）期去除上或下部的葉片或莢果，對產量及植株生理有不同的影響，就產量而言，以上部葉片及下部莢果的重要性較高。上述試驗結果除說明不同部位器官的功能具有程度性的差異，並表示光合物質生產與分配效率的重要，對其相關之生理作用應予深入探討。

Hume and Criswell (11) 與 Stephenson and wilson (15) 指出大豆於生殖生長期，尤其是種子充實階段，豆莢所在節位的葉片爲其光合產物的主要供源，其他節位之葉片則隨與豆莢距離的增加而所能提供之光合產物漸少，顯示大豆植株每一節位上之器官有自成一單位的表現。本試驗利用大豆此一特性，選擇植株不同部位之葉片與豆莢，假設某一特定節位爲一供源／積儲單位，探討在生殖生長期二者之間的關係，以期對大豆產量生理有更完整的瞭解。

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材料與方法

試驗採用之材料爲早熟大豆品種十石（Shih-Shih, SS），於72年7月2日（夏作）播種於臺中縣霧峰鄉臺灣省農業試驗所農場。播種時每穴播4粒種子，出土後間拔爲2株，行株距爲 50×10cm。肥料用量爲N：P_2O_5：K_2O＝24：50：70kg/ha，均以基肥一次施於田間，生育期間進行中耕，除草及培土一次，其他田間管理按一般慣行栽培法進行。試驗小區面積爲$12\times3m^2$，重複3次。

在開花（R1）期於自基部算起之第6、8與最頂端等之節位掛牌標示，以爲取樣依據，田間大豆之平均節數爲12節。自 R1 期開始每週取樣一次，每次自每小區逢機選取5株，三小區合計15株，按不同節位摘取葉片與莢果，自 R5 期開始再將豆莢區分爲莢果壁及種子。每次取樣均測定葉面積與各部位之乾物重，化學分析方面包括葉綠素，全氮與非構造性碳水化合物（total nonstructural carbohydrate, TNC）之測定。

測量葉面積係將大豆葉片自葉柄著生處剪下，擦拭乾淨後以葉面積測定儀（LI-3000 leaf area meter, LI-COR Company, U. S. A）測定之。乾物重係將葉片，莢果壁與種子依節位區分後，於送風乾燥機中以80°C烘乾 48hrs後秤量。經由不同生育期測得三個節位之葉面積與葉片乾重，可求得比葉重（specific leaf weight, SLW），係葉重與葉面積之比值（mg/cm^2）。由莢果壁及種子乾重可求得種子充實度，以種子乾重與莢果總乾重之比值（seed/pod ratio）表示之，又可計算種子之充實速率（seed growth rate, SGR, mg/day）。

葉片葉綠素濃度係將採自田間新鮮葉片依不同節位區分後，取定量材料於預冷之研缽中研磨至完全均質化，經紗布過濾，以絕對乙醇於 4°C 及黑暗情況下萃取 30min，在低溫狀況離心（1,000g）5min，取上層液以分光比色計（Perkin-Elmer Model 55 spectrophotometer）於649及665nm測定，計算chlorophyll a＋b之量[22]。

TNC與N素之分析方法係將烘乾後之材料以Wileymill經40目（mesh）篩磨粉，種子以Phillips HR-2170磨粉機磨粉，粉狀樣品置於 PE 塑膠瓶中再以80°C烘乾24hrs後，以內外蓋封口置於塑膠袋內密封，供分析用。TNC係仿Smith[14]法分析，稱取適量（100-500mg）樣品，以 0.5% takadiastase（"Clarase 40,000", Miles Laboratories Inc., U. S. A）於 40°C 水解 44hrs，再以Shaeffer-Somogyi copperiodometric titration method定量。N素係以Semi-micro kjeldahl 方法測定。

試驗期間大豆生育期之判定係依Fehr and Caviness[10]所定方法行之。

結　　果

依大豆葉片著生節位，取第6、8及頂端節位之葉片，分別測定其葉綠素，非構造性碳水化合物（TNC）及氮素之濃度，並由葉片乾重及面積計算比葉重。三個節位葉片之葉綠素含量的變化趨勢大致相同（圖1A），第6及第8節自開花期（R1），而頂端節位自豆莢形成期（R3）開始，葉綠素含量逐漸增加，三個節位均於種子開始充實時（R5期）達到最高葉綠素含量（2.6-2.8mg/g. f. w.），節位間差異不大，自R5 期後葉綠素含量逐漸降低，R7 期有再次回升的現象，成熟時各節位老化即將脫落葉片之葉綠素含量均低於0.5mg/g. f. w.。估計各節位從R5期至最末期，葉片葉綠素含量約下降85%。

葉片N素濃度變化如圖1B所示。三個節位中以第6及第8節位之變化趨勢較爲相同，二者均於開花期（R1）有最高N素濃度，分別爲4.2%及4.8%，而後隨豆莢及種子之形成而大幅下降，至 R5 期約爲3.7%。種子充實初期又行回升，於 R5.5期達次一高峯，第8節位較高約4.3%，第6節位僅3.8%，而後隨種子迅速充實而大幅下降，葉片脫落前之 N素濃度約爲2.5%。頂端節位葉片 N 素濃度之變化趨勢與上述二節位略有不同，在豆莢形成時（R3期）濃度最低，僅爲3.1%，隨後迅速上升，R5期達

最高濃度4.1%，一直維持到R5.5期後隨種子迅速充實而降至最低濃度2.2%。種子充實期間（R5.5至R7期），第6、8與頂端節位葉片N素濃度分別降低了1.25%、1.8%及1.8%。

生殖生長期間三個節位葉片TNC濃度變化趨勢（圖2A）與葉綠素含量之變化趨勢相同，均於種子開始充實（R5期）時達到最高TNC濃度，以第6節最高，爲20.3%，第8節次之爲19.8%，頂端節位最低爲17.0%。R5期以後TNC濃度大幅下降，R6期稍有回升，各節位葉片於脫落前之TNC濃度均低於5%。

三個節位葉片之比葉重變化趨勢並不一致（圖2B）。第6節葉片於R1期之比葉重爲3.6mg/cm²，隨後逐漸上升，至R5期（種子開始充實）最高（4.5mg/cm²），其後大幅下降，R5.5—R6.5間變化不大，葉片脫落前又下降至3.8mg/cm²。第8節位葉片比葉重之變化趨勢與第6節位大致相同，但數值較高，R1至R5期大幅上升而達第一次高峯（4.9mg/cm²），R5.5至R6.5期葉片又逐漸累積乾物質而達最大比葉重5.1mg/cm²，隨後持續下降。頂端節位之比葉重自R3期便迅速增加，於R6.5期達最大值6.6mg/cm²，而後亦呈下降趨勢。比較R5期以後三個節位之比葉重，發現愈頂端節位之比葉重愈大，葉片所累積乾物質愈多，差異極爲明顯。

莢果壁N素濃度變化趨勢相當一致（圖3A）。各節位均於豆莢形成時（R3期）具最高濃度由下而上依次爲3.4%、3.7%與3.95%，而後隨種子之發育與充實而持續下降，成熟期（R8）之最低濃度以頂端節位0.7%最高，第8節位0.5%次之，第6節位僅爲0.4%。豆莢自最初形成到成熟期，各節位N濃度之下降幅度，第6節爲3.0%，第8節爲3.2%，頂端節位3.3%。

自豆莢形成（R3期）開始三個節位莢果壁所累積之氮素即大量增加（圖3B）），約於R5.5期達到最大累積量，此時第6、8及頂端節位依次爲2.26，2.19及2.83mg/pod。而後第6與第8節之變化趨勢相同，均於R5.5期開始下降，至成熟時分別含有0.48及0.63mg/pod之N素。頂端節位莢果壁所累積之N素於R5.5期達最高值（2.8mg/pod）後亦持續下降，成熟時爲0.95mg/pod，均較低節位莢果壁N含量爲高。以各節位莢果壁最大N素累積量（R5.5）及成熟時莢果壁N素含量估計，三個節位莢果壁N素之減少量由上而下依次爲1.88，1.56及1.78mg/pod，以最頂端之節位最多，而第8節最少。

生殖生長期三個節位莢果壁TNC濃度變化趨勢大致相同（圖4A）。豆莢形成時（R3期）第6與第8節位莢果壁具有最高TNC濃度，分別爲10.2%及9.8%，頂端節位則爲6.6%，R3期後TNC濃度逐漸下降，R5.5期第6、8及頂端節位莢果壁之TNC濃度依次爲4.8%、4.0%及3.3%，均爲各節位之最低濃度，隨後又迅速升高，接近R6期時又達另一高峯，依次爲8.0%、6.8%與6.7%，頂端節位於此時方達到生育期最高濃度。成熟期三個節位莢果壁之TNC濃度由下而上依次爲6.7%、6.2%與6.0%，略有較下位者濃度較高之趨勢。

莢果壁乾物重之變化趨勢如圖4B所示，三個節位莢果壁之乾物重均自豆莢形成時（R3期）迅速增加，於R6.5—R7達最大乾物累積，各節位之累積量由上而下依次爲163.1、147.8與136.8mg/pod，隨著豆莢成熟莢果壁乾重亦有小幅度下降。

三節位種子於充實期間之N素濃度變化不太一致（圖5A），第6節位種子N素濃度在6.1～6.6%間呈起伏變化，幅度甚小；第8節位種子於R5至R6.8間N素濃度變化不大，而後大幅上升，R7.2時高達7.4%，種子成熟前又大幅下降。頂端節位種子N素濃度於R5期爲三節位中最低者，僅有5.1%，而後隨著種子充實逐漸升高，成熟時種子N素濃度以頂端節位7.2%最高，第8節位6.9%次之，第6節位最低爲6.6%。

種子N素累積量（mg/pod）之變化如圖5B所示，三個節位種子均自種子開始形成（R5期）以後迅速累積N素，於R5至R6期間三節位N素累積量差異不大。R6期後，第6節位之累積速率最快，第8節位次之，而頂端節位最慢，至R6.5期第6節位種子N素累積量爲14.8mg，已達R8期的80%，而此時第8節位及頂端節位種子之N素累積量分別僅爲R8期的66%及53%，差異甚大。就種子N素累

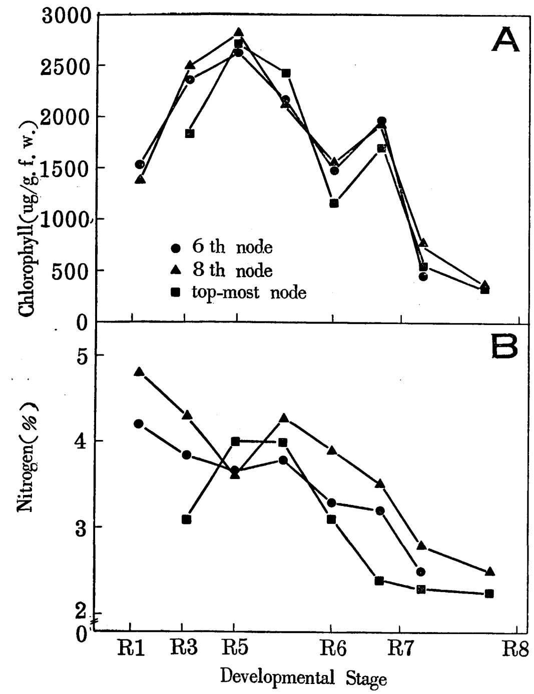

Fig. 1. Changes of (A) chlorophyll and (B) N concentrations in the soybean leaves at 3 node positions during reproductive growth period.

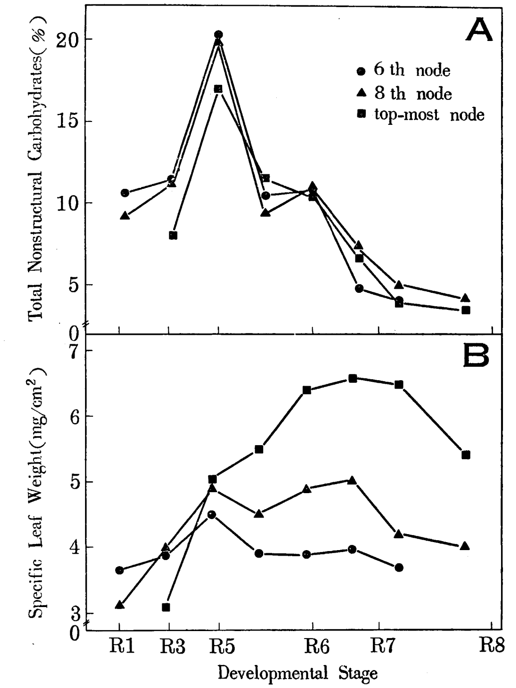

Fig. 2. Changes of (A) TNC concentration and (B) specific leaf weight of soybean leaves at 3 node positions during reproductive growth period.

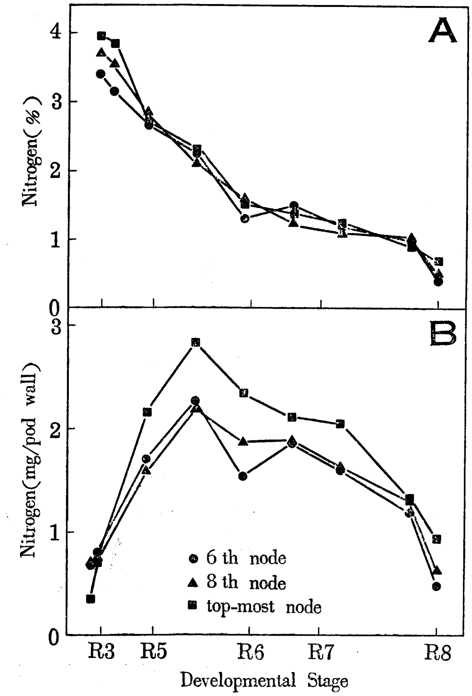

Fig. 3. Changes of (A) N concentration and (B) N amount present in soybean pod walls at three node positions during reproductive growth period.

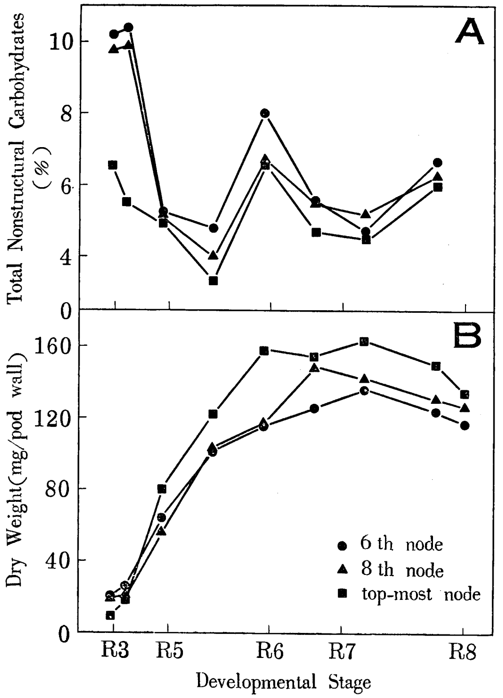

Fig. 4. Changes of (A) TNC concentration and (B) dry weight of soybean pod walls at three node positions during reproductive growth period.

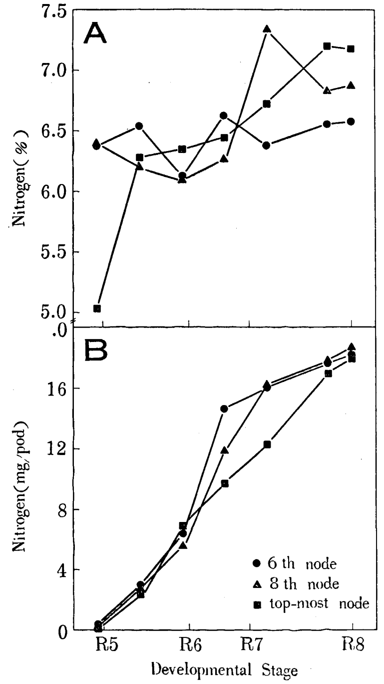

Fig. 5. Changes of (A) N concentration and (B) N amount present in soybean seeds at three node positions during reproductive growth period.

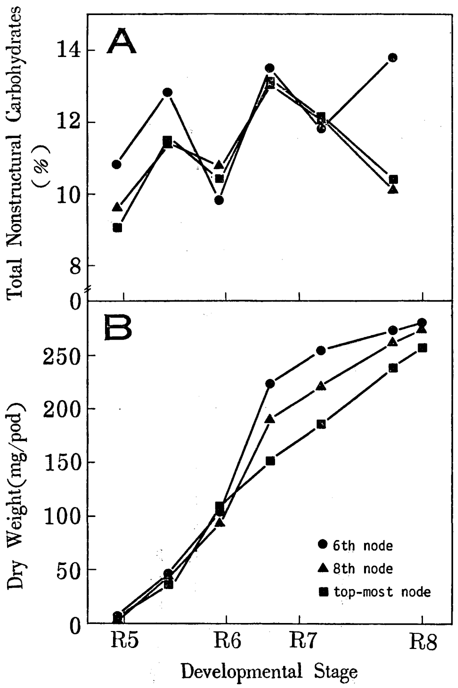

Fig. 6. Changes of (A) TNC concentration and (B) dry weight of soybean seeds at three node positions during reproductive growth period.

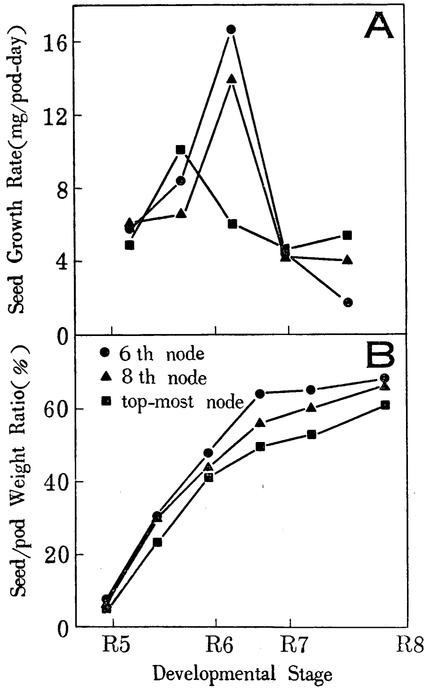

Fig. 7. Changes of (A) seed growth rate and (B) seed/pod weight ratio at three node positions of soybean plants at successive reproductive growth stages.

積模式而言，第 6 節位以種子充實前期的累積速率較高，頂端節位於 R6至 R8期間呈緩慢的直線累積，第 8 節位則兼有二者之特性。 種子成熟時三節位N素累積量約爲18mg，差異不大。

種子自發育後 TNC 濃度在 9 —14%間呈起伏變化(圖 6A)，除第 6 節於末期大幅上升而差異較大外，變化趨勢頗爲一致。成熟時以第 6 節位 TNC 濃度最高，達13.8%，第 8 與頂端節位約爲10%左右。

種子乾物質累積 (mg/pod) (圖6B) 與N素累積之趨勢相同。三節位於 R5至 R6間乾物累積之差異不大， R6 期後以第 6 節之累積最爲迅速，第 8 節次之，頂端節位最緩慢，至 R6.5 期三節位種子所累積之乾物質佔 R8 期乾物質之比率，由下而上依次爲80%、70%及59%。成熟時以第 6 節位有最大乾物重，第 8 節次之，而頂端節位最低。

圖7 A說明種子充實速率 (SGR, mg/pod-day) 之變化情形。第 6 及第 8 節位的變化模式頗爲相似，種子充實初期二者之速率差異很小，而後第 6 節位種子之充實速率均遠大於第 8 節位，其中尤以最大累積速率時之R6.5期差異最大，分別爲 16.8及 13.7mg/pod-day

。頂端節位SGR自R5期便逐漸增快，於 R5.6達最高峯，但其值僅爲10.0mg/pod-day，均遠較其他二節位低，而後逐漸下降，但成熟前其SGR反較其他二節位高，種子仍然繼續充實與累積乾物質。

以種子乾重對莢果重之比值表示種子充實度之變化（圖 7B ），三個節位的變化趨勢大致相同，皆自種子形成（R5期）後迅速充實，於 R5—R6.5間呈直線增加，至 R6.5期第 6 節位之充實度已達成熟期的93%，其種子充實最爲迅速，而此時第 8 節及頂端節位之充實度，依次僅達 R8 期的84%及81%。三節位之充實度呈節位次序，以第 6 節位最大，第 8 節次之，而頂端節位種子充實度最低，比較成熟期之充實度，三節位由下而上依序爲68.4%、66.6%及61.2%。

討　論

依據Fehr and Caviness[10]之方法判斷大豆生育期，R1爲始花期， R2爲盛花期，R3爲豆莢形成期，R4爲全莢期，自R5期方有種子出現爲種子形成期，R6爲種子飽滿期，R7期豆莢開始黃化爲種子生理成熟期，至R8期種子完全成熟爲成熟期。現將本試驗分成二部份，即 R1—R5期（豆莢期）及R5—R8期（種子充實、成熟期），探討植株上，中、下三個供源一積儲單位間之關係。

一、開花期至種子形成前（R1至R5期）之供源一積儲關係

由圖1A及圖2A得知第 6 及第 8 節位供源葉片葉綠素及 TNC濃度皆自 R1期，而頂端節位葉片自R3期起大幅上升，均於R5期達最大值，顯示出大豆植株進入生殖生長期後葉片之供源能力（ source capacity）大幅增加，而此時豆莢（莢果壁）爲主要積儲部位（15），然而由於莢果壁爲一暫時性的積儲組織（20），而且種子尚未形成，因此其積儲需求並不强烈，導致此時期供源葉片所合成的光合產物除了利用於生長之維持及消耗外，可大量累積於葉片，此時期葉片 TNC 濃度可高達20%，比葉重（SLW）亦直線增加，尤以第 6 及第 8 節位之比葉重於R5期已達全生育期最大值。 Egli *et al*[9]亦認爲大豆在種子充實期比葉重和碳水化合物之累積有密切相關 ； 王等[1]指出大豆進入生殖生長期後，植株乾物質迅速累積，於 R6 期達全株最大乾物重。這些結果均顯示大豆植株進入生殖生長期後，葉片光合能力增强，供源能力大幅增加，以因應發育中莢果壁或即將發育之種子的需要。

莢果壁 TNC濃度（圖4A）在其最初形成時最高，且以第 6 節最高，第 8 節次之，頂端節位最低，與葉片 TNC濃度相若，顯示積儲部位 TNC 濃度與供源部位有極密切的關係存在。R3期後莢果壁TNC濃度大幅下降，推測可能是提供豆莢內逐漸發育而成的種子及構成莢果壁本身組織需要所致。

葉片N素濃度的變化（圖1B）與葉綠素及TNC之表現不同，中、低節位均在 R1期有最高N素濃度，而後大幅降低，而頂端節位於R3期屬於幼葉，葉片尚未發育完全，故N素濃度較低，而後由於葉片之生長與發育而升高，於R5期達最大濃度。三節位莢果壁N素濃度之變化模式相同，亦在最初形成時最高，而後迅速下降，推論其原因，除了因供源葉片 N素供給不足外，可能部份N素自莢果壁轉移至發育中的種子，此外莢果壁乾物質累積速率（ 圖4B）遠高於 N 素累積速率（圖3B），亦爲導致N素濃度大幅下降的原因之一。

二、種子形成至種子成熟（R5—R8）期之供源一積儲關係

自種子開始形成後，三個節位供源葉片葉綠素含量均大幅下降，雖然 chatterton[5]未能發現葉綠素含量和光合作用間之明確關係 ， Secor *et al*[13] 却報告大豆老化過程中 ， 葉綠素濃度與 RuBP Carboxylase活性同時下降，本試驗中又發現葉片TNC濃度及比葉重均於 R5—R5.5期大幅下降，推測至少最下節位之光合能力在此時已成爲限制因子。此一時期由於種子迅速形成及充實而成爲主要積儲[11]， 對供源葉片有大量需求，尤以下位節種子最爲明顯，而最上位節種子因形成較晚，積儲需求較小，可由圖6A種子TNC濃度（R5—R5.5）以第 6 節位最高，頂端節位最低得到證明。

葉片及莢果壁 TNC濃度在R6時略有上升，其後又再度下降，尤以葉片更爲明顯，各節位間差異並不顯著但莢果壁TNC濃度似乎以較下位節者較高，莢果壁爲一暫時性的貯存庫[20,8]， 而葉片老化

係自下節位開始，因此下位節莢果壁含有較高 TNC 濃度是否具有補償作用，值得進一步探討。葉片TNC濃度在種子充實期（R5）至老化脫落前（約R7）平均約下降15%，顯示葉片內大多數的 TNC 都能向外轉移 ，Egli *et al*[9] 認爲葉片內碳水化合物會隨種子充實而大量轉移至種子，因而濃度大幅下降，Hume and Criswell[11] 與Stephenson and Wilson[15] 以 ^{14}C 標定試驗也有相同結果，顯示積儲需求有自供源移出 （ drain ） 同化物質的能力，間接影響供源葉片之光合作用及生理活性；Dunphy and Hanway[6] 更認爲生長後期葉片中TNC能否順利轉移到種子，爲決定產量的重要因子之一。

葉片N素濃度自種子充實期即大幅下降，莢果壁N素濃度亦自R5期大量減少，顯示種子對 N素之需求頗大。老化即將脫落的葉片內仍含有大量N素（2.2%—2.5%），與王等[2] 之結果相符， 但與Streeter[16], Boon-Long *et al*[4] 及Zeiher *et al*[24] 之結果（0.9—1.1%）相差甚大。本研究室多年來對許多品種之調查結果顯示本省大豆老化葉片 N素含量過高，無法充分轉移，對N素需求頗大的大豆種子而言，或爲產量的限制因子。莢果壁 N 素之轉移效率高，R8時 N 濃度均在 1.0%以下，但TNC濃度則爲 6 %，較葉片爲高； Jones and Simmons[12] 在玉米發現植株營養部位N素之轉移受到限制，然而 C 素之轉移却頗具效率，因此推論二者可能經由不同的代謝途徑轉移。大豆莢果壁中N與TNC向種子的轉移方式是否也有類似區別，尙待試驗證明。

由於種子充實期間大量 N素及 TNC 自葉片移出，導致比葉重於種子充實末期大幅下降，此一現象在三個供源葉片內均顯著存在，且有愈下位葉者出現愈早之現象，顯示在植株內由於不同節位葉片發生（ ontogeny ）時間不同而呈現不同生理活性。頂端節位葉片發生最晚，活性最大，且在族羣中的受光態良好，因此具有最大的光合生產力及最高比葉重。上位葉葉片較厚，所含乾物質較多，可能有利其生理活性之維持，因此就大豆植株而言，上位葉片光合能力之持續時期長短可能對大豆產量有較大意義。

莢果壁在R5期前扮演積儲角色，累積大量N素及 TNC，而後於種子充實期轉移至種子而成爲供源組織，Egli and Leggett[7] 指出莢果壁在供源葉片及種子間扮演緩衝（ buffering ）的角色。Egli *et al*[8] 認爲葉片和莢果壁可提供種子所需N素之20%，若處於缺 N狀態，則比例可提高至60%。Thorne[19] 更認爲對生育期短的品種而言，莢果壁所貯藏及再轉移的同化物可有效的延長種子充實期。依據 Thorne[19] 之計算方法，估計莢果壁所轉移乾物重對種子產量之貢獻（20-30mg/pod），三個節位由下而上依序爲 2.8%、3.2%及4.7%，顯示種子的乾物累積主要來自現階段葉片所進行的光合作用，再轉移物質可能以N素及其他較微量之營養要素爲主。

由種子對莢果乾重之比率（圖 7B）得知下位節之種子充實度最高，向上依序遞減，較下節位種子並有較高的百粒重（第 6 、 8 與頂端節位分別爲 17.7、17.2與16.2g），顯示低節位種子形成較早，充實速率較高（圖7A），至 R6.5期時已累積R8期之 80%乾物質，上位節種子之充實速率較低，R6.5期乾重僅爲成熟種子之 70%（第 8 節位）與 59%（頂端節位）。上述結果顯示上位節葉片雖有持續較長的光合成能力，莢果壁亦累積較多的乾物質與 N素，但並無法直接表現於產量，推究其原因，可能爲下位葉片較早老化，上位葉片必須供應部份下位莢果的積儲需要，或上位葉片亦呈現功能性老化（functional senescence），但無法由外觀及葉綠素與N素濃度表現測知[23]。

綜合本試驗各項結果，大豆植株各供源與積儲單位在 R5（種子形成）期以前的表現大致相同，顯示此一時期二者間之關係較爲單純，自種子開始形成以後，種子爲主要積儲，莢果壁爲暫時性積儲兼有供源能力，又由於不同節位葉片之發生時序導致生理活性的差異，增加了供源葉片與積儲種子間關係的複雜性。綜觀大豆植株各器官的表現，以下位莢果與上位葉片對產量的重要性較高，延緩大豆葉片生理活性老化以提高產量業爲多數學者所注意，但如何提高高節位莢果種子充實速率及產量表現似爲更可行之途徑，今後對有關供源與積儲間之關係，亦有更加深入瞭解的必要。

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Source and Sink Relationshpi at Different Nodes of Soybean Plants[1]

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Summary

This paper investigated the relationship between source and sink organs at 3 different node positions of soybean plants during the reproductive growth period. Using Shih-Shih as experimental variety, samples were taken weekly from the 6th, 8th, and the upper-most nodes, starting from the flowering (R1)stage. Dry weight and concentrations of N and total nonstructural carbohydrates (TNC) were analyzed for every sample. Leaf area and leaf chlorophyll content were also determined. Results showed that the source-sink relationship was similar among three node positions for every measured character before R5 (beginning seed) stage. Specific leaf weight and leaf TNC concentration increased and no apparent decrease in leaf N concentration were observed. Pod wall possessed the function of temporary sink during the same period. After the beginning of seed formation, the seed became the primary sink and the pod wall acted as both a sink and source organ. Differences in physiological activities due to the sequential ontogeny among leaves of different nodes added the complexity between the source leaf and the sink seed. For the upper node, there was a continuous increase of specific leaf weight. Pod wall contained higher amounts of dry matter and N. However, seed yield, seed filling rate and seed/pod ratio were lower when compared with those of the lower nodes. In other words, the upper leaves could maintain higher physiological activity when plant was approaching maturity whereas the lower seeds were more important to grain yield. Delaying the senescence of leaf and/or increasing the filling rate of upper pods may improve the relationship between source and sink, and hence increase the grain yield.

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高、低温下稻熱病菌病原性之研究[1]

簡 錦 忠[2]

摘要 本研究目的在探討低溫（1月）及高溫（7月）季節所分離之稻熱病菌，在不同溫度下之病原性，以及對穗稻熱病之侵害程度。結果顯示於試驗溫度範圍（20～32°C）內均具有病原性，但無論高溫或低溫季菌株，皆在24°C及28°C下較其他溫度（20及32°C）病原性强，只有低溫菌株中之L-6S於20°C 下之危害程度較高溫(24、28及32°C)下為嚴重。低溫季菌株與高溫季菌株比較時，前者之病原性平均較適合低溫環境下侵入危害。但兩者對穗頸稻熱病之感染率都很高而且差異不大，只是低溫菌株之病原性稍微高些。稻株抽穗前之幼穗最易被感染，抽穗後對穗稻熱病之抵抗性漸次增加。在田間七個供試品種，低溫季菌株接種區之穗稻熱病罹病率平均較高溫季菌株接種區為高，而且品種間之差異頗大，即稉稻臺農67號及臺南5號最感病，秈稻臺中低脚烏尖及高雄大粒清油亦具相當的感受性，而關東51號對供試四個菌株均較具有抵抗性，其次為稗稈稻及高脚柳州。本研究之稻熱病菌菌株均自葉上病斑分離所得，稻穗利用脫脂棉包纏法及注射法接種，均可作為今後穗稻熱病抗病篩選方法之用。

臺灣光復初期糧食不足，由於政府正確的農業政策及有關技術者之努力以及農民的勤勉，漸次提高單位面積的產量，民國34年度每公頃收穫量只有1,287公斤，到民國71年度提升到3,765公斤，提高單位面積產量達2.93倍，雖然目前人口比光復當時增加約三倍，但因生活水準提高，稻米消費量漸次減少，稻米生產反而過剩。近年來由於稻米生產過剩，提倡水田轉作。本省稻栽培面積最高峰時，達到794,228公頃（民國51年）(4) 而今年（七十四）年預定栽培面積為591,600公頃，收穫量預定2,200,000公噸。雖然稻田一部分轉作栽培其他作物，但稻栽培面積尚有60萬公頃（1、2期合計），仍為臺灣栽培面積最大之糧食作物。稻作病害方面，尤其是稻熱病，雖許多學者及專家的努力研究，至今已得相當良好的成果，但每年尚有發生危害，例如去（七十三）年度據農林廳統計(5) 葉稻熱病發病面積18,412公頃，防治面積累積156,795公頃；穗稻熱病發病面積23,113公頃，防治面積累積262,495公頃之多。防治稻熱病所費用的財力及勞力相當龐大，實在尚有一些不可忽視之問題存在。

氣溫、相對濕度或其他環境因子的變化，皆可直接影響稻熱病之發生與進展，因此稻熱病病勢之進展與氣象因子之關係頗密切且複雜(24)。在臺灣稻熱病的流行，一般第一期稻作較第二期稻作猖獗，即稻熱病之發生相受季節的變化，往年顯示3～4月開始發病，4～5月（葉稻熱病）及5～6月(穗稻熱病)發病率提高，7～8月發病率降低，9～10月再稍微增加，11月以後逐漸減少，終告平息。究其原因係溫度和季節影響發病及其流行(16,23)。據 Tseng等(25) 將本省稻熱病菌34菌株分別作溫度試驗結果，發現在34°C 培養時，第二期作所分離之菌株，其生長速率顯然比第一期作菌株快。於本省中部（本所圃場）測定周年稻熱病發生消長試驗時，發現較低溫季（2～3月）稉稻之感病程度比秈稻嚴重，但高溫季（7～8月）裡，秈稻反較稉稻罹病，且秈稻上所形成之病斑多為大型且呈赤褐色(3)，可能在不同氣溫下生育的稻苗影響其抵抗性程度(19)，且影響流行之環境因子，氣溫比相

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對濕度較爲重要，假如寄主之感病性固定不變時，將由寄生者與其發育適溫之關係，而影響病害之流行[18]。另外關於穗稻熱病當稻穗尚在葉鞘內時感受性較大，抽穗後抵抗性增加，而且愈往後期抵抗性愈强。不過環境因子尤其是氣溫之變化，可直接影響抵抗性持續期間的長短，一般而言，穗稻熱病持續之期間比葉稻熱病顯著的短[17]。如果行人工接種，主穗及第一次分蘖穗在抽穗後8～11天最爲罹病[21]。但穀粒稻熱病較穗頸稻熱病之潛伏期間爲短[11]。對葉片具有病原性與無病原性兩種菌株，用脫脂棉包纏法接種穗頸部位，其潛伏期間約 2～4天，而且兩種菌株均具有病原性[14]，另外對秈稻葉片未具病原性菌株，於未抽穗前，利用注射法接種亦可危害稻穗[11]。環境如溫度變化，影響稻株之感病性，已如上列報告所述，但秈稻在高溫季較感病，稉稻在低溫較罹病，是否與病菌菌株有關，尚未見研究報告。因此本研究在探討高溫及低溫環境下所分離之稻熱病菌，測定在不同溫度條件下，對稻葉及穗病原性之異同，以供抗病育種之參考。

材料及方法

一、病原菌之分離：於本所圃場設置旱田式病圃[2,6]，每月播種供試稻（稉稻：崑山五香稉，臺南5號及臺農67號；秈稻：高雄大粒清油，高脚柳州及臺中低脚烏尖）一次，使其自然感染稻熱病，並於低溫季（1月25日）及高溫季（7月10日），採集各品種上的感病型病斑。經單胞分離後，培養於稻節培養基內，待菌絲長滿後放置於定溫箱（5°C）內保存。

二、供試稻之培育：測定各菌株對葉稻熱病之病原性用的供試稻臺農67號、臺南5號、高雄大粒清油及臺中低脚烏尖等四個品種，在溫室內播種於 7×7×10cm 鋁質盆，每盆播20粒，待稻苗生長達本葉3～4片時供接種之用。又供試臺農 67號及臺南5號兩品種，經育苗後插植於直徑16cm，深19cm的塑膠盆內，每盆插三叢，每叢插三支苗，在溫室內栽培，待抽穗時每天以紙條標示抽穗日期，約抽穗一半時，行人工接種穗頸稻熱病。另在田間插植臺農67號等七個品種，依一般方法管理，於抽穗期（稻穗先端抽出葉鞘上約3cm時作爲標準）時行人工注射接種。

三、高、低溫季所得菌株在不同溫度下之病原性測定：每次接種前，自保存菌株中取出稻節培養繁殖並作成胞子懸浮液（5×10^5 個胞子／ml），供人工噴霧接種之用。接種後放入不同溫度（20，24，28及32°C）之接種箱內，保持適當濕度並經24小時後，移置於溫室內，一週後調查每支秧苗之感病型病斑（S）數。

四、高、低溫季所得菌株對穗稻熱病之病原性測定：將脫脂棉浸漬於上述胞子懸浮液中，然後取出包纏於每支穗頸，使其感染。接種後放於28°C定溫接種箱內，保持適當濕度經24小時後，移置於溫室內，經二週後調查各處理之罹病穗率。在田間亦用上述胞子懸浮液，利用注射法，將胞子懸浮液注入葉鞘內側，即自劍葉葉鞘下部向上插入，注入懸浮液直到從葉鞘上端溢出爲止，然後用塑膠袋套上，經二天後取除塑膠袋，再經二週後調查各品種之稻穗罹病率。

結　　果

一、高、低溫季所得菌株在不同溫度下之病原性

本試驗供試菌株有高溫季（7月）採自高雄大粒清油（H—1S），臺中低脚烏尖（H—2S）崑山五香稉（H—3S）及臺農67號（H—4S）；低溫季（1月）採自高脚柳州（L—5S），高雄大粒清油（L—6S），臺南5號（L—7S）及臺農 67 號（L—8S）等八個菌株。接種用菌株以 yeast starch agar 上繁殖經2週後，作成胞子懸浮液（5×10^5 個胞子／ml）行人工噴霧接種。接種後放入不同溫度（表1）之接種箱內，經24小時後移置於溫室內，一週後調查每支秧苗之感病型病斑（S）數。由本次所得結果（表1及圖1、2）獲知試驗溫度 20～32°C 之範圍內均可侵入形成病斑，無論在高溫或低溫季所得菌株，皆在24°C及28°C下較易感病。高溫季菌株 H—2S及H—4S 之之病原性較弱，前者（H—2S）在32°C下對四種供試稻苗均無病原性，而且在 28°C 下對臺農67號及臺南5號，24°C

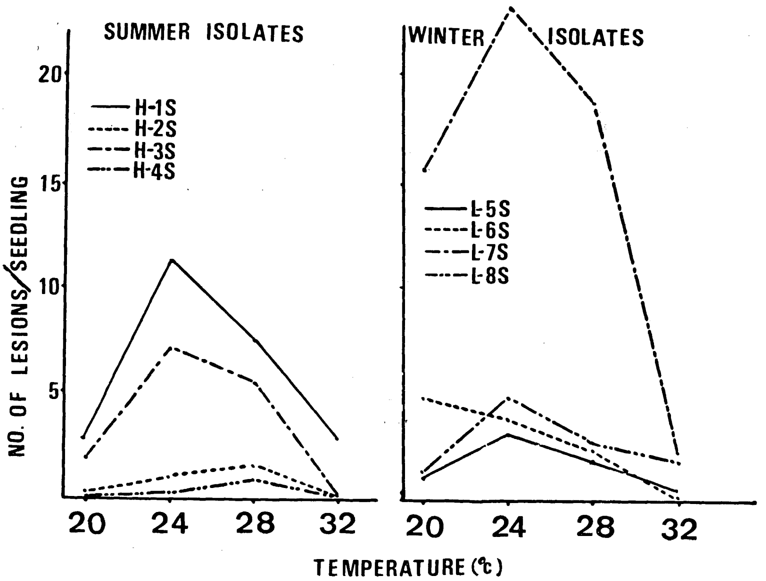

圖1. 高、低溫季所得稻熱病菌菌株在不同溫度下之病原性（四個品種平均）

Fig. 1. The effect of temperature on the pathogenicity of summer and winter isolates of *Pyricularia oryzae*. (average of four varieties of rice)

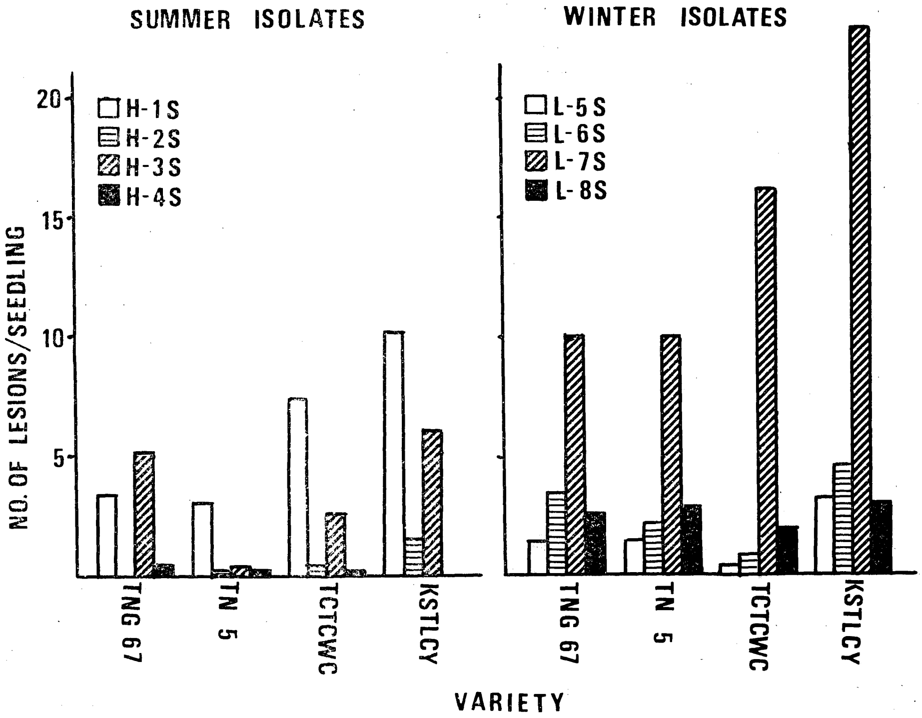

圖2. 高、低溫季所得稻熱病菌菌株對不同品種之病原性（四種不同溫度平均）

Fig. 2. The pathogenicity of summer and winter isolates of *Pyricularia oryzae* on four rice varieties

表1.高、低溫季所得稻熱病菌菌株在不同溫度下之病原性

Table 1. The effect of temperature on the pathogenicity of summer and winter isolates of *Pyricularia oryzae*.

Variety	Summer isolate	No. of lesions/seedling temperature (°C) 20	24	28	32	Winter isolate	No. of lesions/seedling temperature (°C) 20	24	28	32
Tainung 67	H—1S	0.00	7.35	4.10	2.28	L—5S	1.63	3.60	0.45	0.10
Tainan 5		0.75	4.15	3.73	3.18		0.65	1.68	2.30	1.13
T.C.T.C.W.C.*		5.83	14.10	8.88	0.93		0.30	0.25	0.78	0.25
K.S.T.L.C.Y.**		4.45	18.73	13.18	4.95		1.80	6.88	3.75	0.48
Tainung 67	H—2S	0.00	0.00	0.00	0.00	L—6S	4.38	4.98	4.40	0.28
Tainan 5		0.08	0.33	0.00	0.00		3.05	3.85	1.83	0.03
T.C.T.C.W.C.*		0.20	2.28	1.95	0.00		2.10	1.00	0.25	0.33
K.S.T.L.C.Y.**		1.00	1.40	4.05	0.00		9.70	5.55	2.78	0.53
Tainung 67	H—3S	0.56	8.35	12.20	0.00	L—7S	9.65	15.63	11.80	3.60
Tainan 5		0.00	3.93	0.00	0.00		2.75	17.68	19.60	1.25
T.C.T.C.W C.*		0.60	6.30	3.10	1.08		18.15	29.08	14.60	3.03
K.S.T.L.C.Y.**		6.33	9.68	6.70	1.69		32.23	30.43	28.63	1.13
Tainung 67	H—4S	0.10	0.20	1.40	0.15	L—8S	1.40	4.20	4.00	0.80
Tainan 5		0.18	0.10	2.45	0.15		2.33	3.08	3.05	3.20
T.C.T.C.W.C.*		0.00	0.45	0.00	0.00		0.03	2.93	2.18	2.63
K.S.T.L.C.Y.**		0.00	0.00	0.00	0.00		0.33	9.43	1.73	0.85

Note: *=Taichung-Ti-Chueh-Wu-Chien; **=Kaohsiung-Ta-Li-Chin-Yu

及20°C下對臺農67號，皆不具病原性，後者（H—4S）在20、24及 32°C 下對臺中低脚烏尖及高雄大粒清油，24°C 下對高雄大粒清油，H—3S在20及28°C下對臺南 5 號，32°C 下對臺農67號及臺南 5 號皆無病原性。自秈稻上所得菌株（H—1S及 H—2S）在秈稻（臺中低脚烏尖及高雄大粒清油）上比稉稻上（臺農 67號及臺南 5 號）之病斑數多。尤其是H—1S更爲明顯，即在 24°C下對臺中低脚烏尖之病斑爲14.10個，對高雄大粒清油達18.73 個之多。低溫季菌株中除L—7S對秈稻之病原性較稉稻爲强外，其餘三個菌株L—5S, L—6S及 L—8S 對秈稻及稉稻的差異不大，而且各菌株對供試四個稻種皆具有病原性。L—6S於 20°C下之病斑數均較高溫（24、28及32°C）下爲多。其餘三個菌株 L—5S、L—7S及 L—8S都在24°C下比其他溫度（20、28及32°C）下之病斑數較多。又採自稉稻的菌株（L—7S及 L—8S）平均病斑數比採自秈稻者（L—5S及L—6S）多。低溫季菌株與高溫季菌株比較時，可知低溫季菌株平均較高溫季菌株之病斑數爲多，而且L—6S在低溫（20°C）下之病斑數最多，此現象表示低溫季菌株比高溫季菌株在此溫度下較適合其侵入危害。

二、高、低温季所得菌株對穗頸稻熱病之病原性：

供試稻在溫室內栽植，待抽穗時用脫脂棉浸漬於上述胞子懸浮液中，然後取出包纏於每支穗頸部

位，接種後放於 28°C 定溫箱內，保持適當濕度24小時，使其感染後再移置於溫室，經二週後調查各處理之罹病穗率。所得結果如表 2 ，無論高溫季或低溫季之菌株，在抽穗當日或穗尚未抽出强迫剝開葉鞘接種之稻穗的感染率都非常高，而且除H—1S外，差異都不大。但低溫季菌株平均較高溫季菌株之病原性有稍强之傾向，而且愈抽穗前，其感染程度愈高，抽穗後漸次具抵抗性，最短抽穗後 2 天，最長 5 天少數尚可被侵害。抽穗前 2 天接種者，大部分之罹病率可達100%，而抽穗當天接種者爲 25～100%，抽穗後罹病率就急劇減低。

在田間栽植臺農67號等七個品種，於抽穗期使用高溫季及低溫季各二菌株，利用人工注射法接種，經二週後調查各品種之罹病穗率。自所得結果（表 3 ），可知低溫季兩個菌株（L—6S 及 L—8S）之平均罹病穗率（50.53%）較高溫季兩個菌株（43.74%）爲高，尤其是 L—6S於七個品種平均罹病率達55.26%，最低爲 H—1S爲38.56%。稉稻臺農67號及臺南 5 號對四個菌株均最爲感受性。而關東51號對四個菌株均呈較抵抗性，其次爲稗稈稻及高脚柳州。本次田間試驗供試菌株均採自葉片上的病斑所得，並利用注射法接種，對稻品種之罹病程度差異頗明顯，可作今後穗稻熱病篩選上應用。

表2. 高、低溫季所得稻熱病菌菌株對穗頸之病原性

Table 2. The pathogenicity of summer and winter isolates of *Pyricularia oryzae* on necks of rice panicles.

Days before(−) or after(+) heading	Percentage of neck blast (%)							
	Tainung 67				Tainan 5			
	H—1S	H—4S	L—6S	L—8S	H—1S	H—4S	L—6S	L—8S
− 2	75.0	100.0	100.0	100.0	50.0	66.7	100.0	100.0
− 1	60.0	100.0	80.0	100.0	30.0	50.0	77.8	83.0
0	55.0	100.0	66.7	88.9	25.0	47.5	52.9	65.0
+ 1	10.0	50.0	45.0	45.5	12.0	33.4	40.0	40.0
+ 2	6.0	25.0	33.0	25.0	9.1	20.0	20.0	25.0
+ 3	0.0	6.0	30.0	10.0	4.0	5.0	15.0	18.0
+ 4	0.0	0.0	10.0	0.0	0.0	0.0	5.0	10.0
+ 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0

表3. 高、低溫季所得稻熱病菌菌株對稻品種之穗的病原性

Table 3. The pathogenicity of summer and winter isolates of *Pyricularia oryzae* on panicles of seven rice varieties

Variety	Disease incidence of panicle blast (%)			
	H—1S	H—4S	L—6S	L—8S
Tainung 67	40.00	87.50	95.45	80.00
Tainan 5	49.09	95.00	92.50	77.42
Pai-Kan-Tao	26.67	33.33	20.83	30.49
Kanto 51	15.00	10.00	13.33	10.00
Kao-Chueh-Liu-Chou	21.89	27.95	57.89	24.24
Kao-Shiung-Ta-Li-Ching-Yu	60.00	35.00	53.68	42.31
Taichung-Ti-Chueh-Wu-Chien	57.30	53.64	53.13	56.10

討 論

臺灣稻熱病之發生，一般第一期稻作較第二期稻作嚴重，其主要原因據Hashioka [23] 指出，主要爲氣溫對病原菌之發育，侵入寄主體以及寄主受溫度之影響，會使寄主隨生育而漸次增加抵抗性等，直接影響稻熱病之流行相。稻熱病菌之形成附着器及侵入寄主之適宜溫度範圍分別爲16～24°C及20～28°C [7]，因本省田間自然溫度，第一期作秧苗期至本田分蘖初期之氣溫範圍爲 15～20°C，分蘖盛期之氣溫範圍爲 20～25°C ，即自本田分蘖初期至盛期，環境因子十分有利於發病，而氣溫愈昇高則愈不利於發病 [17] 但有時在第二期稻作秈稻之穗稻熱病亦會異常大發生 [8] ，另於本省中部設置病圃觀察周年稻熱病發生流行相時，曾發現夏季高溫下，秈稻感受性較稉稻爲强，且秈稻所出現病斑多爲褐色大型病斑 [3] 。由本試驗測定高溫季及低溫季菌株在不同溫度下之病原性 ，以及對穗稻熱病之危害程度，所得結果可知試驗溫度範圍（20～32°C）內，供試稻均會被感染危害，無論高溫季或低溫季菌株，一般在24°C及28°C時均較其他溫度下者爲感病，只有菌株 L—6S於20°C 時病斑數比高溫下者爲多，此現象表示，在低溫季所得的菌株（L—6S）於較低溫時較適合其侵入危害。另高溫季所得菌株中，H—1S在高溫（32°C）下，其病原性比其他菌株爲强，此菌株與 Tseng [25] 等，發現之結果在34°C溫度下培養稻熱病菌時，第二期稻作分離之菌株 ，其生長速率顯然比第一期稻作菌株快頗相似。又據橋岡 [20] 指出，如於稻苗生育適溫（26～28°C）爲標準，另設高溫（29～32°C）或低溫（15～25°C）之氣溫下，作人工接種時，稻苗一般在低溫下呈感病性，即無論施肥之質及量如何 ，低溫下生育之稻苗的葉片含有成分，與氮肥過量的生育相相同呈感受性 ，而在高溫下生育之稻苗葉片與缺乏氮肥的生育相呈抵抗性，故罹病程度具有差異 。又稻苗之葉片及葉鞘的碳氮比（C/N ratio），係隨氣溫及土壤溫度之比例增加，到達生育適溫時最爲抵抗性，超過此溫度者其比例略被攪亂的傾向 [17] 。

過去本省對稻熱病之研究皆偏重葉稻熱病 ，故對穗稻熱病之研究資料較少。僅橋岡 [19] 報告，本省穗頸稻熱病被感染時期，爲抽穗前及抽穗中之稻穗極爲感受性，抽穗後抵抗性遂漸增加，而且愈往後期抵抗性愈强。又伊藤及島田 [12] 亦指出稻抽穗時較呈感受性，且通過帶菌率很高的葉舌部位，因其接觸該部位而提高被感染的機會。同時幼穗尚在葉鞘內 ，尚未抽出前時常已被病菌感染爲害 [1] 。本次供試菌株對臺農67號及臺南 5 號於溫室內，利用棉花包纏接種結果，在高溫季或低溫季所得菌株之感染率都很高而具差異不大。不過一般而言，低溫季菌株比高溫季菌株之感染性程度略高。在抽穗當天比抽穗後之稻穗爲感病，此現象因爲抽穗後稻穗之組織逐漸硬化， 使病原菌不易侵入 [19] ，因此寄主之抵抗性增加，但稻穗還包在葉鞘內，强迫剝開葉鞘接種時，比抽穗當日之感染率提高很多，在田間常見到抽穗則呈白穗者頗多，如詳細觀察時，可發現穗頸並無被害，在穗稈中央部位受害，養分不能送達穗部而呈白穗，即在葉舌部位危害之狀況下，在此部位形成分生胞子而隨小雨或露水流入孕穗中的葉鞘內，侵入尚未抽出的幼穗 [1] 。鈴木及吉村 [15] 指出如利用注射法接種，測定穗稻熱病之病原性，稻品種間差異頗顯著，同時在接種前追施氮肥可促進發病率。千葉等 [10] 亦指出， 供試葉稻熱病與穗稻熱病，得很高的相關係數（r＝0.90以上）。另橋岡 [19] 報告，本省第一期作稻抽穗時期之降雨日數及降雨量比第二期作多，又第一期作葉稻熱病之發生，使該期作稻葉或葉鞘上附着較多的病原菌，因此在抽穗時， 其感染率較高 [20] 。吉野 [13] 認爲稻熱病菌侵入穗頸危害所需時間，因溫度不同而異同，即在24°C下需要12.5小時最短，其次在26.5°C下需12.9小時仍與24°C差異不大，但 29°C下需14.2小時才能完成其侵入行動。據Hashioka [23] 指出臺灣稉稻一般比秈稻爲抵抗性，但本次試驗所供試秈稻兩個品種（臺中低脚烏炎及高雄大粒淸油）具相當的感受性，這現象與近年來本省出現稻熱病菌生理小種I group之增加，似有密切之關係 [8,22] 又田間試驗所利用之菌株係自葉片病斑所得，利用注射接種法，其結果得知稻品種間之罹病率差異頗明顯，可供爲今後穗稻熱病篩選方法之依據。

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Comparison of Pathogenicity Among Summer and Winter Isolates of *Pyricularia oryzae*[1]

C. C. Chien

Summary

Four winter and four summer isolates of *Pyricularia oryzae*, the former were isolated in January and the latter in July, were used in this study to compare their differences in pathogenicity to rice plants at 20, 24, 28 and 32 C. The winter isolate L-6S was more virulent at 20C while the other three isolates L-5S, L-7S and L-8S were more virulent at 24 and 28C. The winter isolates were more virulent to rice leaves than the summer isolates at 20C. In the greenhouse tests for neck blast, we found that winter isolates were more virulent than summer isolates but no difference was observed among the winter isolates. Young panicles before heading were very susceptible to blast. However, the resistance increased with time after heading.

Seven varieties of rice were planted in paddy fields to compare their susceptibility to panicle blast. The results showed that Tainung 67 and Tainan 5 were very susceptible; Taichung-ti-chueh-wu-chien and Kaoshiung-ta-li-chen-yu were moderately susceptible; Pai-kan-tao and Kao-chueh-liu-chou were moderately resistant; Kanto51was the most resistant variety. According to the average of the disease incidence of panicle blast on the seven varieties in the field, the winter isolates were more virulent than thesummer isolates. Cotton coiling method and/or injection method were very successful in the inoculations of panicle blast. Therefore, these two methods are recommended for the incoulations of screening tests for resistance of rice vavieties to panicle blast.

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影響稻紋枯病菌生長及菌核形成之因子[1]

張義璋[2]

摘要 供試紋枯病菌 9 個菌株均以 28°C 爲菌絲最適生長溫度。對菌核形成而言，菌株 TC41、TC44、TC87、TC96、TC105、CY83 及 F5 等以 16°C 爲最適溫度，菌株 TC162及 S21 則以 20°C 爲最適溫度，在 32°C 時菌株 TC87 幾乎無菌核形成，但 TC96 則與最適溫度下所形成之菌核量差異不大。當 20°C 與 32°C 兩種溫度交替培養時，顯示 TC44 及 TC87 對高溫比其他菌株較爲敏感。紋枯病菌無論菌絲生長或菌核形成之最適酸鹼度近於 pH7.0。菌絲生長對酸性比鹼性較有耐性；相反地，菌核形成對鹼性較有耐性。水份潛勢（ψ_0）對紋枯病菌之影響亦受溫度所左右。菌株 TC44 菌絲生長於溫度12至 24°C 間之最適水份潛勢爲 −5.1 bars；28 及 32°C 時則爲 −8.0 bars。菌株 TC96 於 12 至 20°C 間爲 −3.4 bars；24°C 時 −5.1 bars；28 及 32°C 則爲 −8.0 bars。菌株 TC44 於溫度 12 至 16°C 間，菌核形成最適水份潛勢爲 −5.1 bars；20 至 32°C 間則爲 −10.2 bars；水份潛勢低至 −34.4 bars 則無菌核形成。菌株 TC96 以 −10.2 bars 爲菌核形成之最適水份潛勢；水份潛勢低至 −34.4 bars，溫度 24～32°C 環境下尚有菌核產生。

水稻紋枯病原菌爲 *Rhizoctonia solani* Kühn（=*Thanatephorus cucumeris* (Frank) Donk），屬於 AG 1 菌絲融合羣，與其他已知之菌絲融合羣（如 AG 2, 3,4）之形態、生理及生態特性等均有其差異性[2,17,20]，其初次感染源、寄主範圍、侵害部位及病徵等亦不盡相同[2,3,4,17]。前人研究，已經瞭解紋枯病菌在田間之消長情形，並確定菌核爲主要初次感染源[1,3–9,13,14]。堀氏[9]將紋枯病之發生分成「菌核浮上期」、「菌核漂流期」、「發病株增加期」、「發病莖增加期」、「上位葉鞘進展期」及「被害決定期」等 6 個時期，其中前 3 個時期以菌核數量爲主，也就是初次感染源的密度影響發病，後面 3 個時期則受溫、濕度等環境因子影響病菌生長及病勢進展。杜及張氏[3,4]連續兩年以菌核捕集網捕集稻田水中紋枯病菌的菌核，發現目前耕作方式下，已無堀氏所述的 6 個發病階段，而以插秧初期田水中的菌核量最多，隨之劇減。筆者等（未發表）發現分蘖期水稻紋枯病發病叢率與插秧初期之菌核密度成正相關。分蘖後期至抽穗期爲叢間傳播期[3,4]，主要靠交織稻葉爲傳播工具，因而成熟期紋枯病發病率又與分蘖期發病率成正相關。蔡氏[10]指出其相關係數頗受氣象因子影響。田間觀察被害稻葉遇不良環境時，如濕度小造成病組織乾燥，病菌停止生長因而減緩病勢進展。由以上觀之，病菌的菌核及菌絲爲紋枯病的主要感染源。高坂氏[8]報告紋枯病菌菌絲以 30°C 爲最適生長溫度，菌核形成之最適溫度則爲 28～32°C。另井上及內野氏[5]指出菌絲生長以 28°C 爲最適，菌核形成則爲 30°C。杜及張氏[4]則報告菌核形成最適溫度，病莖上爲 20～28°C，在 PDA

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上則爲 16°C 。這些溫度上之差異，是否受菌系之影響，值得進一步探討。本研究即探討溫度、酸鹼度及水份潛勢對不同菌株之紋枯病菌生長及菌核形成之影響，期能找出培養大量菌核之條件，供生物防治可行性及其他應用研究之參考。

材料與方法

一、溫度對菌絲生長及菌核形成之影響：

爲瞭解紋枯病菌菌株間菌核形成量之差異，由農試所保存之 *R. solani* AG 1[20] 中選取在32°C 菌核形成量較多之菌株 TC96、S21、F5，較少之 TC44、TC87、TC162 及中間之 TC41、TC105 及 CY83 等共 9 個菌株爲供試材料。各菌株均以 PDA 平板培養，每 2 天更新一次，連續共 3 次，使菌源維持於最旺盛活力之狀況下，然後以直徑 0.5cm 之打孔器，在菌落周圍打取菌絲圓盤，將菌絲圓盤之菌絲面朝下，平置於 PDA 平板上（直徑 9cm 培養皿注入自製 PDA 15ml），然後分別放置於 4 、 8 、12、16、20、24、28、32、36及 40°C 之恆溫箱中，培養16、24、32及48小時後量取各菌落大小。至於菌核形成之數目，因各菌株皆陸續形成菌核，而且相隣菌核常融合一起，難以計算其數目，故等全部成熟及穩定後，採用乾重量比較之。本試驗共進行 3 次，每次 3 重複。

二、酸鹼度對菌絲生長及菌核形成之影響：

供試菌分別選取在 32°C 形成菌核能力較多之菌株 TC96 及較少之 TC44 。菌源準備與前項試驗同。供試培養基爲美國 Difco 公司出品之 PDA，滅菌後以無菌之 IN 的 HCl 及 NaOH 調整其酸鹼度，成爲 pH 4、5、6、7、8及 9，培養基冷却凝固前（約 40°C）再測 pH 值，結果分別爲 4.2、5.0、5.8、6.9、8.2 及9.0。移菌後分別置於20、24及 28°C 之恆溫箱中，每一處理 9 重複。pH 培養後之調查與前項試驗同。

三、滲透水份潛勢（ψ_0）對菌絲生長及菌核形成之影響：

供試菌株亦爲 TC44 及 TC96 ，菌源準備與前項試驗同。本試驗分別於12、16、20、24、28及 32°C 等 6 種溫度下進行。供試培養基以 Difco 公司之 PDA 爲基礎培養基，以 KCl 爲溶質，調節PDA 之水份潛勢（ψ_0）爲—5.1、—8.0、—10.2、—12.4、—14.6、—21.2、—25.6、—34.4、—47.7及－65.7 bars 。對照之 PDA 爲－3.4 bars[18,19] 。各處理 6 重複，移菌培養後之調查與前項試驗同。

試 驗 結 果

一、溫度對菌絲生長及菌核形成之影響：

溫度低於 4°C 或高於 40°C 時，紋枯病菌即停止生長。 36°C 雖經30日培養，菌絲僅生長約 1mm；8°C 時多數菌株如 TC96、TC105、TC162、TC87、S21 及 F5，尚能緩慢生長，但經30日之培養尚無法長滿培養皿，亦未形成菌核。供試 9 個菌株均以 28°C 爲最適生長溫度，而以 TC96生長最快，28°C 溫度下培養16小時菌絲單向生長達 2.03cm ，推算每小時生長速率爲 1.27mm ，各菌株生長速率如圖 1 所示。

菌核形成以 24～28°C 溫度下形成最快，約接種後60小時即開始有菌核形成，80小時菌核轉爲褐色。其他溫度下紋枯病菌形成菌核所需培養時間分別爲：32°C 需70小時；20°C 需80小時；16°C 需96小時；12°C 則需132小時。各種溫度下，菌核均陸續地形成，至培養 3 週後即趨穩定，本試驗均於30日測定菌核量。除 TC162 及 S21 兩菌株以 20°C 之菌核量最多外，其他菌株均以 16°C 之菌核量最多（圖 1 ）。

爲進一步探討溫度對菌核形成之影響，將各菌株分別培養於 20°C 或 32°C 溫度下 3 日或15日後，再調換溫度並繼續培養至30日後，調查菌核形成量。結果如表 1 所示，菌株 TC96 對溫度最不敏感；TC87 最敏感，於 32°C 溫度下培養 3 日後移入 20°C 培養時，已大幅降低菌核量，於 32°C 溫

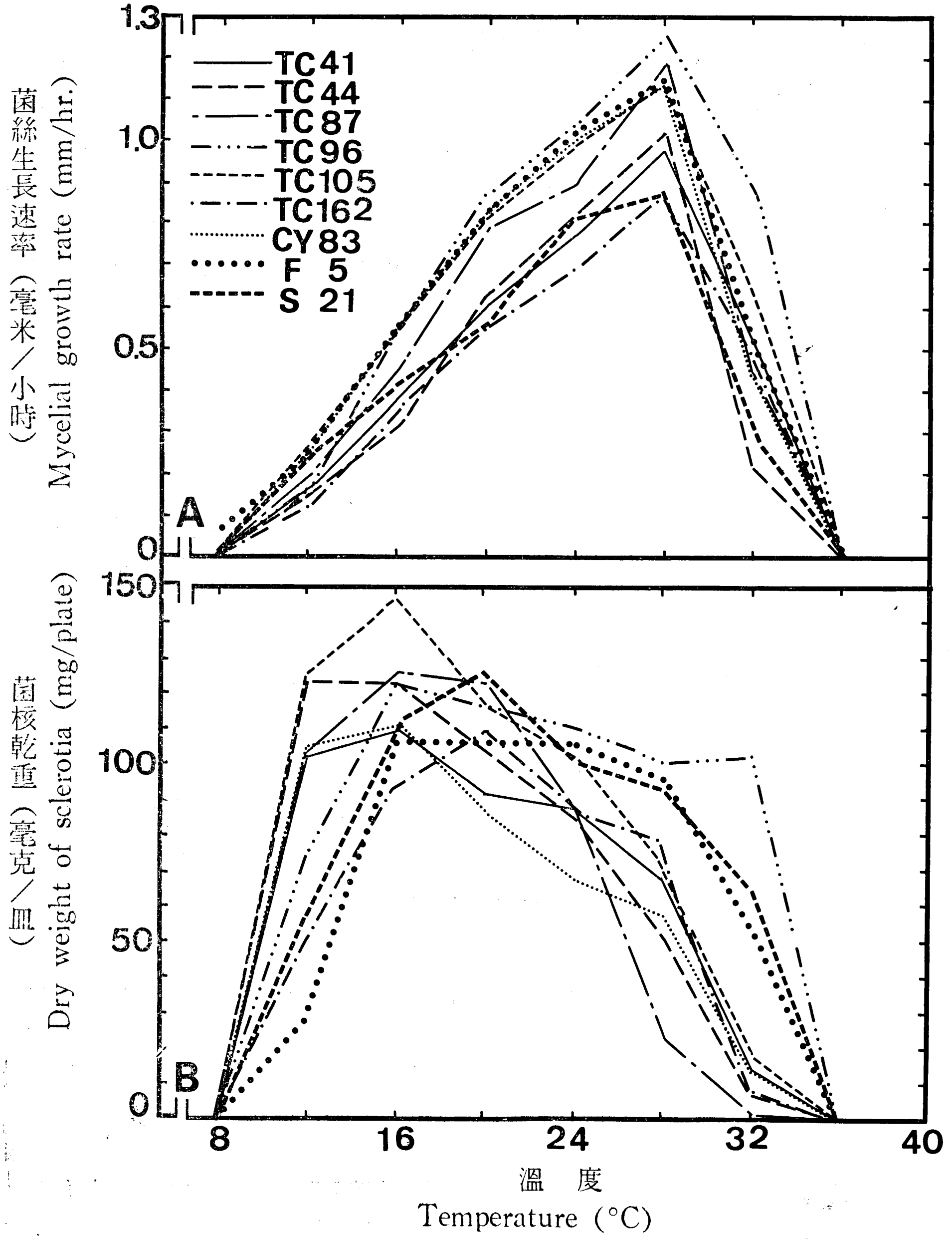

圖1.溫度對不同菌株稻紋枯病菌生長（A）及菌核形成（B）之影響

Fig. 1. Effect of temperature on mycelial growth (A) and sclerotial formation (B) of various isolates of *Rhizoctonia solani* AG 1.

度下培養15日後，再移至 20°C 培養則幾無菌核形成。

表1. 改變溫度對不同菌株紋枯病菌菌核形成之影響

Table 1. Change of temperature on sclerotial formation of various isolates of *Rhizoctonia solani* AG 1.

培養期間[a]（日數） Incubation period[a] (days)			各菌株之菌核乾重（毫克／皿） Dry weight of sclerotia produced by each isolate (mg/plate)								
20°C		32°C	TC41	TC44	TC87	TC96	TC105	TC162	CY83	S 21	F5
3	→	27	112.9	15.1	2.9	118.3	98.3	36.3	22.0	89.1	34.2
15	→	15	112.5	66.8	24.2	139.2	82.0	56.1	45.2	125.9	113.9
27	←	3	94.1	51.8	15.6	144.6	84.0	44.6	24.0	109.1	108.3
15	←	15	83.1	16.8	2.0	143.6	50.0	43.0	43.4	113.7	91.7
0		30	34.3	1.8	0.0	101.9	6.9	6.2	13.6	73.3	52.7
30		0	97.0	98.4	94.0	111.1	111.2	123.8	95.2	126.7	110.3

a) 各菌株均培養30日

[a] All isolates were incubated for 30 days totally.

二、酸鹼度對菌絲生長與菌核形成之影響：

菌絲生長最適酸鹼度，兩菌株間略有差異。菌株 TC44 爲 pH7.0 ，偏酸至 pH4.2 時其生長尙無顯著差異；但 pH 値升高至8.0時，菌絲生長已顯著緩慢。菌株 TC96 生長最適酸鹼度爲 pH5.0 至6.0左右，其生長曲線與 TC44 相類似（圖 2 ）。

酸鹼度對菌核形成量之影響亦因菌株及溫度而有差異，菌核形成量以 TC96 菌株較多，而且較不受酸鹼度之變化所影響，但鹼性較有利菌核形成。TC44 菌株受酸鹼度影響，以20及 24°C 兩種溫度下較大， 28°C 時酸鹼度之影響較小，三種溫度下均以鹼性較有利菌核形成（圖 2 ）。

三、滲透水份潛勢（ψ_0）對菌絲生長及菌核形成之影響：

滲透水份潛勢對紋枯病菌之影響，受溫度影響而有差異。溫度高時菌絲生長之最適水份潛勢降低。菌株 TC44 於溫度12至 24°C 間之最適水份潛勢爲 −5.1 bars；28 及 32°C 時則爲 −8.0 bars 。菌株 TC96 於12至 20°C間之最適水份潛勢爲 −3.4bars；24°C 時爲 −5.1 bars；28 及 32°C 則均爲 −8.0 bars 。當水份潛勢低至 −47.7 bars 時，培養 3 日尙未見有生長之現象（圖 3 ）。

菌核形成能力而言，菌株 TC44 所需之最適水份潛勢與菌絲生長所需者相類似，12及 16°C 以 −5.1 bars 爲最適，20至 32°C 之間則以 −10.2 bars 爲最適水份潛勢，當水份潛勢低至 −34.4 bars 時，各種溫度下均未見有菌核形成。菌株 TC96 以 −10.2 bars 之水份潛勢爲最適於菌核形成，當水份潛勢低至 −34.4 bars 時，在溫度24至 32°C 之間尙有菌核產生。因此，TC96 菌核形成能力對水份潛勢耐度較高（圖 4 ）。

討論與結論

病原菌之 9 個供試菌株均以 28°C 爲生長最適溫度，與井上及內野氏[5]報告相同，但高坂氏[8]報告以 30°C 爲生長適溫。菌核形成之先後與菌絲生長速率相關，一般當菌絲長滿培養皿後12小時即可見菌核產生。因此24至 28°C 溫度下菌核最早形成。以菌核總重量而言，16至 20°C 爲最適溫度

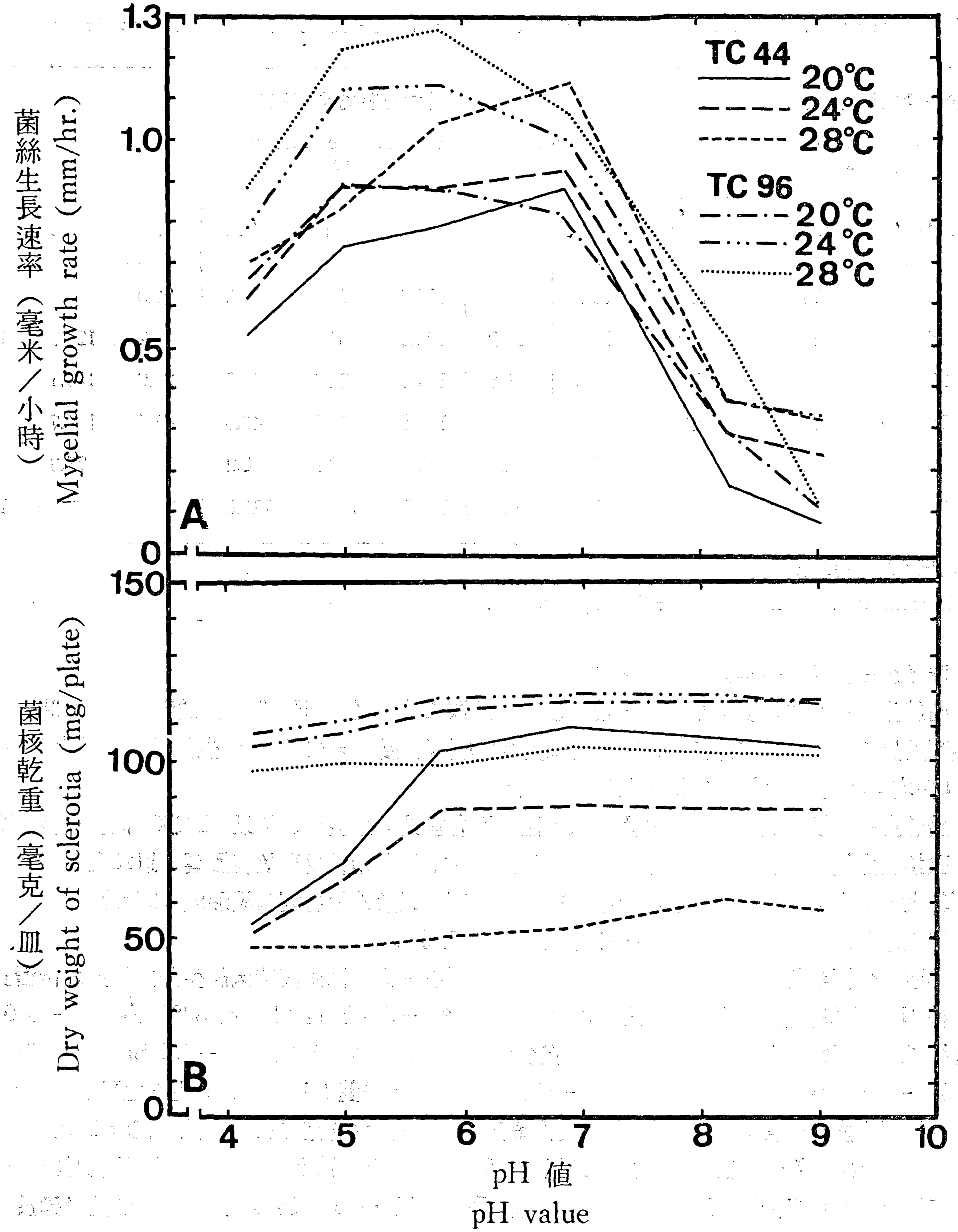

圖2. pH 值對稻紋枯病菌生長（A）及菌核形成（B）之影響

Fig. 2. Effect of pH value on mycelial growth (A) and sclerotial formation (B) of *Rhizoctonia solani* AG 1 (isolates TC 44 and TC 96).

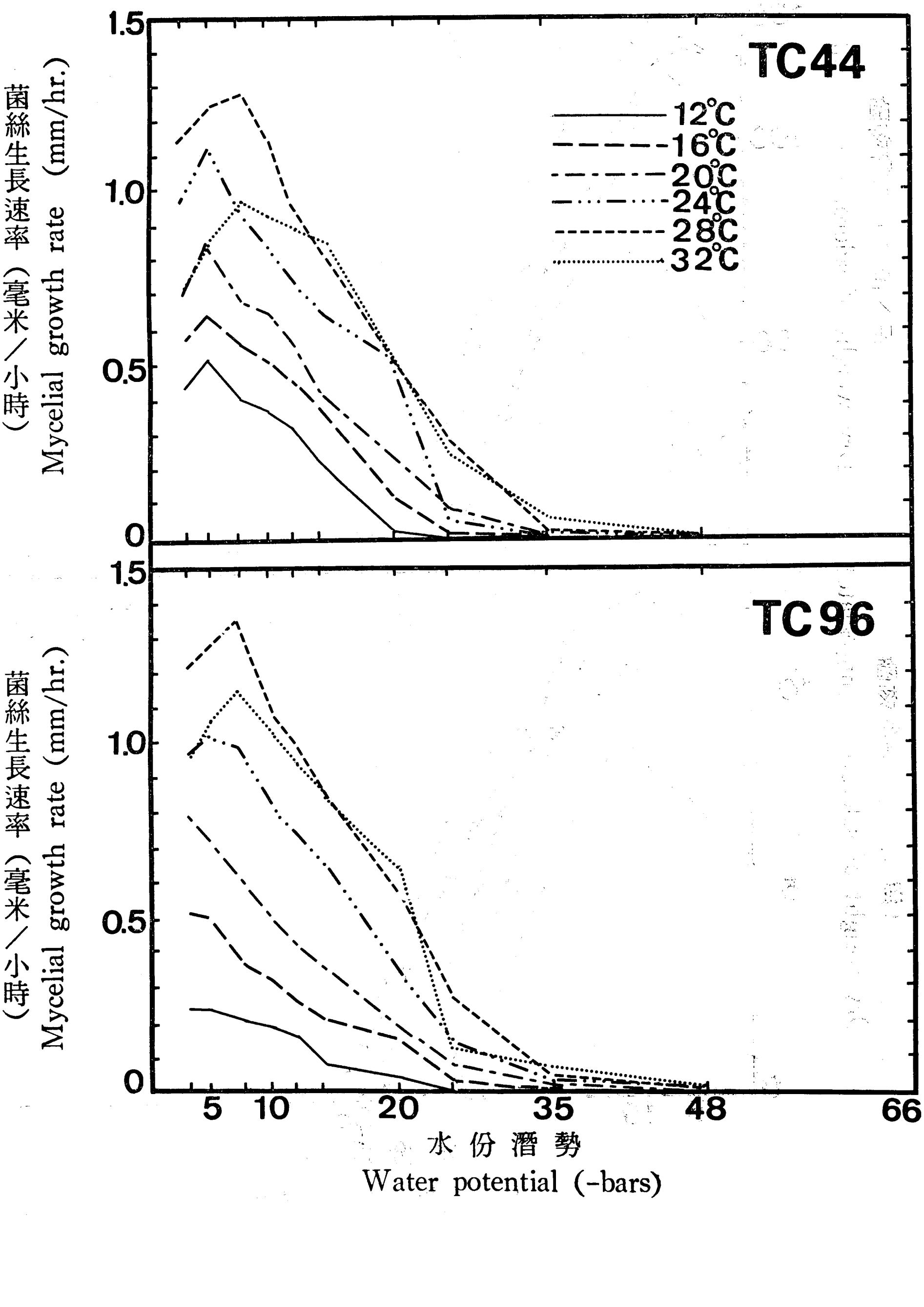

圖3. 水份潛勢對稻紋枯病菌生長之影響

Fig. 3. Effect of water potential on mycelial growth of *Rhizoctonia solani* AG 1 (isolates TC 44 and TC 96).

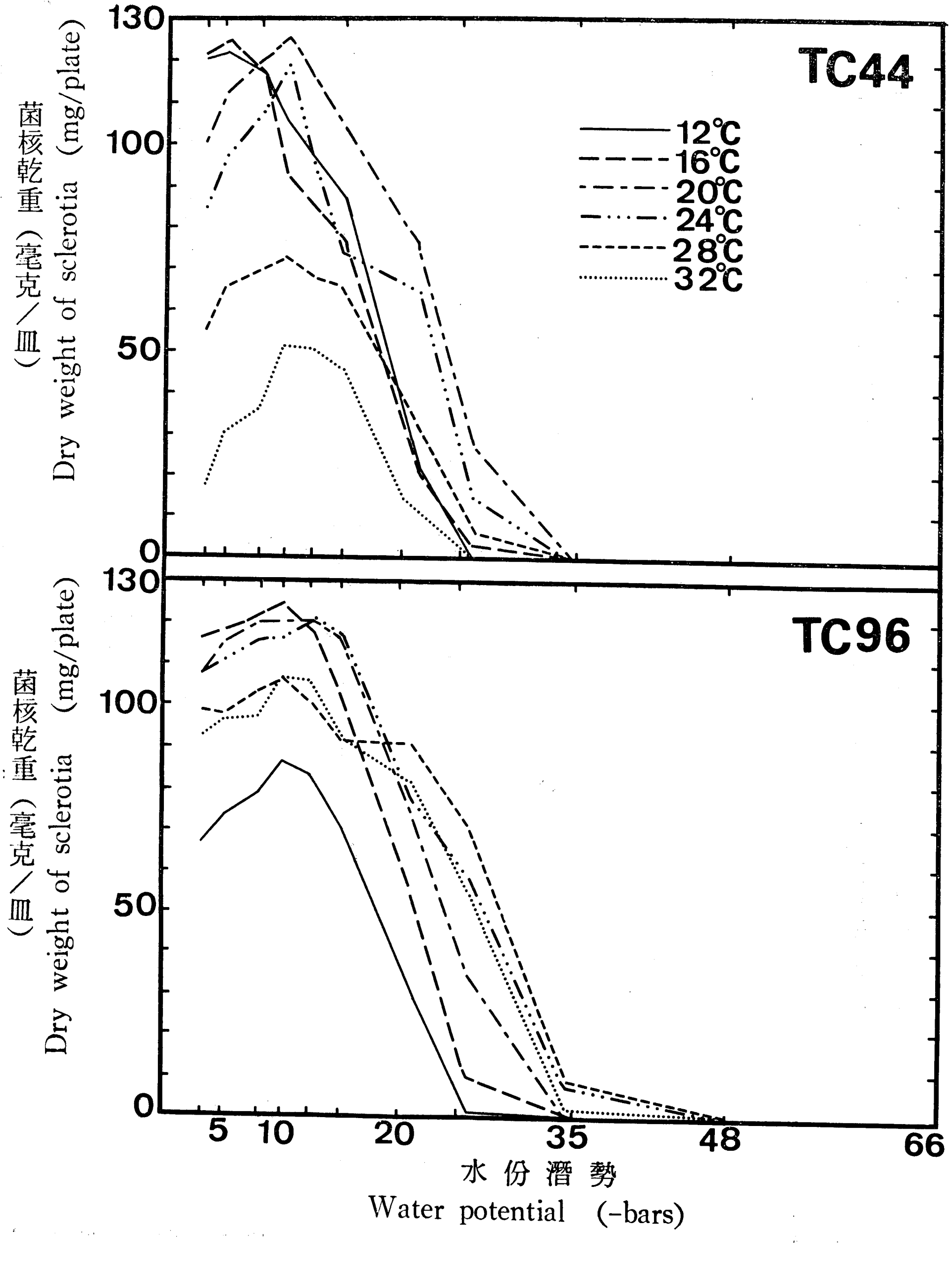

圖4. 水份潛勢對稻紋枯病菌菌核形成之影響

Fig. 4. Effect of water potential on sclerotial formation of *Rhizoctonia solani* AG 1 (isolates TC 44 and TC 96).

(圖1)。高坂氏[8]及井上和內野氏[5]分別報告菌核形成最適溫度爲 30°C ，井上和內野同時指出溫度高時形成之菌核較小。但據本研究進行中所發現，菌核大小與溫度並無絕對相關，反而與菌株之間較有密切關係，例如 TC96 之菌核比 TC44 形成者較小，後者之菌核又往往相融合而成一片。另由20與 32°C 兩種溫度互調培養之結果（表1），確知菌株間對溫度之敏感性不一，例如 TC41 在 20°C 培養3日或15日再移入 32°C 均提高菌核形成量；反之，TC87 菌核形成量則甚低。TC96 對溫度較不敏感。雖然菌核形成量與菌株有關，但各菌株之最適溫度均爲16至 20°C 之間，28至 32°C 時菌核形成量已大幅減少。本項結果與日本報告有異，究爲研究方法不同所得之結果，抑或兩地有地域性菌株差異之存在？尚待進一步探討。

培養基的最適酸鹼度無論對紋枯病菌之菌絲生長或菌核形成均爲中性，紋枯病菌在偏酸培養基上菌絲生長比在鹼性培養基上生長爲快，亦即較耐酸性；菌核形成量則適得其反，鹼性比酸性培養基上之菌核量爲多（圖2）。

Bruehl 和 Cunfer[11] 報告，不同菌對調整培養基水份潛勢之溶質有不同之敏感度，*Sclerotinia borealis* 在蔗糖爲溶質之培養基上生長速率，比利用氯化鉀爲溶質快兩倍；*Typhula idahoensis* 和 *T. incarnata* 兩種菌對鹽類和蔗糖之忍受性則表現一致。紋枯病菌對蔗糖、 NaCl 及 KCl 等3種溶質之敏感性，本試驗之預備試驗曾測試發現三者間頗爲一致，故本試驗僅以 KCl 爲調整水份潛勢之溶質。紋枯病菌之最適滲透水份潛勢，受溫度提高而降低。溫度 12°C 時 TC96 菌絲生長最適水份潛勢爲 −3.4 bars，但 32°C 時則降爲 −10.2 bars；菌株 TC44 亦從 −5.1 bars 降爲−8.0 bars（圖3）。菌核形成亦有相同趨勢，菌株 TC44 在 12°C 以 −5.1 bars 水份潛勢時，菌核形成量最多，但 28°C 時則以 −10.2 bars 水份潛勢情形下，菌核量最多；最低水份潛勢則由 −25.6 bars 降爲 −34.4 bars 。相對的，菌株 TC96 菌核形成能力對水份潛勢耐度較高，在 24至 32°C 環境下，水份潛勢低至 −34.4 bars 時，尚有菌核形成（圖4）。本結果與 Manandhar 和 Bruehl[16] 報告 *Fusarium oxysporum* f. sp. *vasinfectum* 和 *Verticillium albo-atrum* 在高溫時之最適水份潛勢比低溫時爲低之結論相似。相同地， Cook 和 Papendick[12] 亦報告指出病菌最適生長之水份潛勢，可能因溫度之不同而有差異。 Lin[15] 報告，瞭解滲透水份潛勢對病菌生長之影響，有利於預測扁豆根腐病之發病。本試驗結果顯示紋枯病菌偏好較高之滲透水份潛勢。但田間菌核在插秧初期即附著於秧苗上，至分蘖盛期才發芽及侵入致病，這種現象除與滲透水份潛勢有關外，是否與菌核表面微生物有關？尚待進一步探討。

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Effect of Temperature, pH and Water Potential on Mycelial Growth and Sclerotial Formation of *Rhizoctonia solani* AG 1[1]

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Summary

The mycelial growth of nine isolates of *Rhizoctonia solani* AG 1 was found best at 28 C. Isolates TC41, TC44, TC87, TC96, TC105, CY83, and F5 produced most sclerotia at 16 C and isolates TC162 and S21 at 20 C. Isolate TC 87 produced a few sclerotia at 32 C. No signficant difference was observed in sclerotial formation of isolate TC96 between 12 and 32 C. Both mycelial growth and sclerotial formation of *R. solani* AG 1 were found best at or about pH 7.0. However, mycelial growth was more tolerant on low pH medium than that on high pH medium. On the contrary, sclerotial formation was more tolerant on high pH medium than that on low pH medium. The effect of osmotic water potential (ψ_0) on *R. solani* AG 1 was also affected by temperature. The best osmotic water potential for the mycelial growth of isolate TC44 was found at −5.1 bars at the temperatures between 12 and 24 C, and −8.0 bars at 28 and 32 C. For the growth of isolate TC96, the best osmotic water potential was −3.4 bars at the temperatures between 12 and 20 C, −5.1 bars at 24 C, and −8.0 bars at 28 and 32 C. The best osmotic water potential for sclerotial formation of isolate TC44 was found at −5.1 bars at 12 and 16 C, and −10.2 bars between 20 and 32 C. No sclerotium was produced at the osmotic water potential lower than −34.4 bars. Isolate TC96 produced the most sclerotia at −10.2 bars of osmotic water potential at all tested temperatures and produced a few sclerotia at −34.4 bars at the temperatures between 24 and 32 C.

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Host Responses of Peanut Witches' Broom Disease[1]

I-lang Yang[2]

Abstract : The results confirmed that the peanut witches' broom disease (Pn WB) could be transmitted to peanut, tomato, potato, alyce clover, purple bean, globe amaranth, periwinkle, *Ipomoea obscura* and *Ipomoea triloba* by insect vector *Orosius orientalis*, but no infection was found in sweet potato, loofah, cucumber, strawberry, water spinach, balsam pear, paulownia, creeping wood-sorral, chinese morning-glory, *Ipomoea pescaprae*, *Chenopodium amaranticolor* and *C. quinoa*. The PnWB affected plants developed typical witches' broom symptoms, and the symptoms of PnWB on tomato plants resembled those of tomato big bud or witches' broom disease. The sieve elements of PnWB infected plants were stained blue with Dienes' stain in sections of phloem tissues by light microscopic observation, but no blue taining reaction was found in the healthy ones. The fact indicated the presence of mycoplasma-like organism in the infected plants.

Introduction

Witches' broom diseases of legume occurred widely in the tropical areas of the world was recognized as mycoplasmadal etiology, and could be transmitted by leafhoppers or dodders, and had a wide range of host plants (1, 2, 4, 5, 6, 7, 8, 9, 10). Peanut witches' broom (PnWB) was found widely in Taiwan, and occurred severely about 50% of infection on Penghu island and could be transmitted by *Orosius orientalis* Matumura (5, 10). This study was attempted to test the responses of several plants to PnWB. In addition, the Dienes' stain method was also used to clarify the presence of mycoplasma-like organisms (MLOs) in PnWB-affected plants (3, 10).

Materials and methods

The insect vectors (*O. orientalis*) collected from peanut field were reared on healthy peanut plants in cages. Twenty one species (Table 1) of healthy plant seedlings were cultivated in pots in greenhouse. Nymphs of *O. orientalis* were fed on PnWB-affected peanut plants for 7 days aquisition feeding in cages, then transferred to healthy peanut

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1. Contribution No. 1248 from Taiwan Agricultural Research Institute. This project was granted by the Council of Agriculture, R. O. C.
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plants for 16 days. The inoculation feeding was made about 9 to 12 days on test plants with those viruliferous insects. The symptom developments on test plants were observed about 6 months after inoculation feeding in greenhouse (5). The free-hand sections of those test plants stained with Dienes' stain were observed by light microscope (3, 10).

Results and discussion

The results of host responses to PnWB confirmed that peanut (*Arachis hypogaea*), tomato(*Lycopersicum esculentum*), potato (*Solanum tuberosum*), alyce clover (*Alysicarpus nummularifolius*), purple bean (*Phaseolus atropurpurea*) , globe amaranth (*Gomphrena globosa*), periwinkle (*Vinca rosea*), *Ipomoea obscura* and *Ipomoea* triloba were susceptible to PnWB (Table 1. and Fig. 1), but no infection was found in sweet potato (*Ipomoea batatas*), loofah (*Luffa cylindrica*), cucumber (*Cucumis sativus*), strawberry

Table 1. Responses of various plants to peanut witches' broom transmitted by *Orosius orientalis* and staining reactions with Dienes' stain.

Test plants	No. of plants tested	No. of plants infected	Incubation periods in affected plants (days)	Blue staining reaction in phloem*
Lycopersicum esculentum Mill.	12	9	29—52	+
Solanun tuberosum L.	19	2	43—59	+
Alysicarpus nummularifolius DC.	16	12	48—80	+
Phaseolus atropurpurea DC.	8	6	41—68	+
Gomphrena globosa L.	7	5	28—59	+
Vinca rosea L.	37	21	11—47	+++
Ipomoea obscura Ker.	16	5	31—49	+
Ipomoea triloba L.	11	3	41—56	+
Arachis hypogaea L.	56	34	39—85	+
Ipomoba batatas Lam.	9	0**	—	—
Luffa cylindrica Roam.	12	0	—	—
Cucumis sativus L.	6	0	—	—
Fragaria chiloensis Ehrh.	11	0	—	—
Ipomoea aquatica Forsk.	9	0	—	—
Paulownia taiwaniana Hu *et* Chang	8	0	—	—
Momordica charantis L.	12	0	—	—
Oxalis cormiculata L.	31	0	—	—
Ipomoea sinensis Choisy.	19	0	—	—
Ipomoea pes-caprae Sweet.	21	0	—	—
Chenopodium amaranticolor Cost. and Rey.	11	0	—	—
Chenopodium quinoa Willd.	12	0	—	—

*Indicate the amount of cells stained blue in the phloem cells.
**No symptom was observed.

(*Fragaria chiloensis*), water spinach (*Ipomoea aquatica*), paulownia (*Paulownia taiwaniana*), balsam pear (*Momordica charantis*), creeping wood-sorral (*Oxalis cormiculata*), chinese morning-glory (*Ipomoea sinensis*), *Ipomoea pes-caprae*, *Chenopodium amaranticolor* and *Chenopodium quinoa* (Table 1). The PnWB affected tomato plants produced abnormal purple top, auxiliary bud, big bud, curly leaves and green flowers in early infected stage, then developed severe witches' broom symptoms (Fig. 1a). These symptoms resembled to those of big bud or witches' broom on tomato hitherto recorded by some authors (2, 6, 11), however, the relationship between tomato big bud or witches' broom and PnWB was unknown. The symptoms of PnWB-affected periwinkle plants showed same symptoms either transmitted by *O. orientalis* or by *Cuscuta chinensis* (Fig. 1e) (10). All sections from PnWB-affected plants showed specific blue staining reaction in phloem cells with Dienes' stain. These results indicated that the presence of phloem-limited MLOs in the PnWB-affected plants (Table 1). MLOs were abundant in diseased periwinkle tissues than in other hosts, however, the reasons of large amount of MLOs in periwinkle were unknown so far (6). Field investigations of PnWB made in Penghu district revealed that the PnWB occurred severely all over the fields, and the affected peanut plants beared seldom pods (Fig. 1g, 1h). Several plants including alyce clover, purple bean and kidney bean naturally infected with PnWB were suggested to be the important inoculum sources of PnWB in fields.

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Explanation of plates:

Fig. 1. Various plants infected with peanut witches' broom transmitted by *Orosius orientalis*.

(a) Diseased tomato (A) and the healthy plant (B).

(b) Diseased alyce clover (A) and the healthy plant (B).

(c) Diseased purple bean (A) and the healthy plant (B).

(d) Diseased globe amaranth (A) induced phylloid flowers (P), twisted small leaves (L) and the healthy plant (B).

(e) Diseased periwinkle (A) induced phylloid flowers (P), and the healthy plant (B).

(f) Diseased *Ipomoea obscura* (A), diseased *Ipomoea trilola* (B) and the healthy *Ipomoea obscura* (C).

(g) Diseased peanut (A) and the healthy plant (B).

(h) Diseased peanut (A) and the healthy plant (B) in field at Ponghu island.

A
B
1a
A
B
P
1e
B
A
1b
A
B
C
1f
A
B
1c
A
B
1g
P
L
A
B
1d
B
A
1h

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落花生簇葉病之寄主植物反應[1]

楊 一 郎[2]

摘 要

落花生簇葉病可經南斑葉蟬 (*Orosius orientalis* Matsumura)媒介傳染而感染落花生、蕃茄、馬鈴薯、山土豆、賽芻豆、千日紅、長春草、細花野牽牛及紅花牽牛。惟不能感染甘藷、絲瓜、胡瓜、草莓、甕菜、苦瓜、泡桐、酢醬草、白花牽牛、馬廄藤、紅藜及白藜。感染本病之病株顯現綠化花及異常分蘗之典型叢生病徵。在蕃茄罹病株之病徵與過去報告之蕃茄"big bud"或"witches' broom"相近似。本病病株篩管組織經 Dienes' stain 染色觀察,可呈現專一性藍色反應,健株植物則無此反應,此項結果證實各罹病株之擬菌質病原之存在。

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殺蟎劑對二點葉蟎 *Tetranychus urticae* Koch 及加州捕植蟎 *Amblyseius californicus* (McGregor) 之選擇性[1]

吳子淦　林香如　羅幹成[2]

摘要　殺蟎劑對二點葉蟎（*Tetranychus urticae*（Koch））,加州捕植蟎（*Amblyseius californicus*（McGregor））的毒性依藥劑種類不同而有差異。合成除蟲菊類（synthetic pyrethroids）,有機磷劑（organophosphates）及氨基甲酸鹽類（carbamates）藥劑對這二種蟎類有較高的選擇性比值（selective ratio）。其餘類型殺蟎劑對捕植蟎、葉蟎毒性接近。Bromopropylate, binapacryl, dinobuton, propargite, oxythioquinox, smite 及 azocyclotin 七種藥劑對葉蟎、捕植蟎之 LC_{50} 選擇比更小於 1，是綜合防治時可考慮使用的殺蟎劑。

Formetanate, dinobuton 是本文內所用殺蟎劑中對二點葉蟎最有效之藥劑。以 formetanate, dinobuton 之 LC_{50} 濃度分別各經15、16次篩選，結果和原始濃度相比，二點葉蟎對 formetanate 產生11.8倍，對 dinobuton 產生2.5倍的抗藥性。二點葉蟎對 formetanate 具有快速產生抗藥性的能力，因此，該藥劑在田間長期使用時需注意可能發生之抗性問題。

Azocyclotin 的化學結構類似 cyclohexatin，尚未在田間正式使用。二點葉蟎對 azocyclotin 已經有了3.5倍的抗性，可能是對 cyclohexatin 的交互抗性所致。

二點葉蟎（*Tetranychus urticae*（Koch））是世界性分佈的害蟎，爲害作物種類繁多，對新環境適應力强，繁殖迅速。一世代時間可增殖 94.3 倍個體[(3)]。加以極易對藥劑產生抗藥性，因此，近年來已成爲本省重要害蟎之一。

加州捕植蟎（*Amblyseius californicus*（McGregor））曾被用以防治草莓二點葉蟎[(13)]，效果優於 *Typhlodromus occidentalis*（Nesbitt）是一種相當有潛力的葉蟎天敵。可以配合藥劑使用，進行對葉蟎的綜合防治。

單純的使用藥劑防治葉蟎，常會導致害蟎產生抗藥性，使防治藥劑失去效果。故爲了維持藥效，常提高藥劑使用濃度，此舉更大量毒殺原本比較敏感的天敵。甚或藥劑直接刺激、改變害蟎的生理作用，引起害蟎再猖獗[(1)]。爲避免上述不良現象發生，進行害蟎綜合防治時，應以對天敵毒性低的藥劑配合使用。本實驗的目的即在於找出合乎上述條件的藥劑。

1.臺灣省農業試驗所 研究報告第1249號。本研究爲行政院農委會補助計畫草莓葉蟎綜合防治示範（74農建—2—2產植—144號）之一部份。

2.本所應用動物系助理，計畫助理及研究員兼系主任。臺灣省　臺中縣　霧峰鄉。

材料與方法

1.供試蟲源：

二點葉蟎 (*Tetranychus urticae* (Koch))：

TARI 品系：1978年自臺北市臺灣大學採回，迄1985年未接觸任何藥劑。

TAHU 品系：1984年11月由大湖地區草莓園採回。

二點葉蟎飼育方法依何及羅 (1979) 報告[2]。

加州捕植蟎 (*Amblyseius californicus* (McGregor))：

1983年6月自美國夏威夷州農部引進本省。在室內飼育於25×18公分黑色硬紙板上。紙板四周圍以濕棉花，置於28×20公分之淺盤中。盤內加水以維持棉花潮濕，防止捕植蟎逃逸。每日放入有二點葉蟎之大豆葉片飼育捕植蟎。

表1. 殺蟎劑的普通名稱及劑型

Table 1. List of common name and formulation of acaricides tested in this paper.

Common Name	Formulation
Organophosphates	
Ethion	46.5% E C
Prothoate	40% E C
Dialifor	47% E C
Dimethoate	44% E C
Omethoate	50% S C
Organochlorine Compounds	
Dicofol	35% W P
Benzomate	25% E C
Chloropropylate	22% E C
Dinitro and Nitrogen-containing Compounds	
Binapacryl	50% W P
Formetanate	50% W P
Dinobuton	30% E C
Organofluorine Compound	
Nissol	25% E C
Organic Sulfurs and Heterocyclic Compounds	
Smite	55% E C
Propargite	57% E C
Oxythioquinox	25% W P
Organobromine Compound	
Bromopropylate	22% E C
Organotin Compounds	
Cyclohexatin	50% W P
Azocyclotin	25% W P
Fenbutatin-oxide	50% W P
Carbamates	
Oxamyl	24% S C
Carbaryl	85% W P
Synthetic Pyrethroids	
Permethrin	10% E C
Decamethrin	2.8% E C
Cypermethrin	5% E C
Flucythrinate	31.6% E C
Fenvalerate	20% E C
Danitol	10% E C

2.供試藥劑：

本實驗共使用 9 類27種殺蟎劑，列於表 1 。所有藥劑皆以水稀釋。

3.藥劑處理：

培養皿內裝0.3%洋菜膠，膠上放置十石品種大豆初葉 (primary leaf) 一片。葉背朝上，將捕植蟎或葉蟎之雌成蟎移置豆葉上，使用 Burkard Spray Tower噴洒 1ml 藥劑稀釋液。5 種濃度，4 重覆，24小時後記錄死亡情形，並以統計方法分析 LC_{50} 值[9]。

4.抗性二點葉蟎篩選：

將 TARI 品系二點葉蟎飼育於十石大豆植株上，篩選之前先測出其對 formetanate, dinobuton 之 LC_{50} 值，再以 LC_{50} 濃度作爲選汰壓力，使用手持噴霧器將藥劑噴洒在葉蟎及大豆植株上。殘

表2. 殺蟎劑對二點葉蟎，加州捕植蟎的 LC_{50} 選擇性比值

Table 2. LC_{50} Selective ratio of acaricides to *Tetranychus urticae* (TAHU strain) and *Amblyseius californicus*.

Acaricides	LC_{50}(mg/ml) *T. urticae*	LC_{50}(mg/ml) *A. californicus*	LC_{50} Selective ratio*
Organophosphates			
Ethion	>16	0.012	> 1,333
Prothoate	≒10	0.006	≒ 1,667
Dialifor	>16	0.068	> 235
Dimethoate	2.7	0.014	193
Omethoate	0.41	0.0017	241
Organochlorine Compounds			
Dicofol	1.33	0.4	3.3
Benzomate	4.93	3.57	1.4
Chloropropylate	0.38	0.19	2.0
Dinitro and Nitrogen-containing Compounds			
Binapacryl	0.22	0.38	0.58
Formetanate	0.068	0.019	3.6
Dinobuton	0.059	0.23	0.26
Organofluorine Compound			
Nissol	1.02	0.27	3.8
Organic Sulfurs and Heterocyclic Compounds			
Smite	2.0	5.82	0.34
Propargite	2.27	5.57	0.41
Oxythioquinox	1.01	1.31	0.77
Organobromine Compound			
Bromopropylate	0.26	0.33	0.79
Organotin Compounds			
Cyclohexatin	>16	6.12	> 2.6
Azocyclotin	1.63	2.03	0.8
Fenbutatin-oxide	>10	>10	—
Carbamates			
Oxamyl	0.32	0.03	10.7
Carbaryl	>16	0.13	> 123
Synthetic Pyrethroids			
Permethrin	0.54	0.15×10^{-3}	3,600
Decamethrin	0.31	≒ 0.01×10^{-3}	≒ 31,000
Cypermethrin	0.26	0.34×10^{-3}	764
Danitol	0.025	0.098×10^{-3}	255
Flucythrinate	1.99	1.9×10^{-3}	1,047
Fenvalerate	0.35	0.19×10^{-3}	1,842

*LC_{50} of *T. urticae*/LC_{50} of *A. californicus*.

表3. 殺蟎劑對二點葉蟎，加州捕植蟎的 LC_{90} 選擇性比値

Table 3. LC_{90} Selective ratio of acaricides to *Tetranychus urticae* (TAHU strain) and *Amblyseius californicus*.

Acaricides	LC_{90}(mg/ml) *T. urticae*	LC_{90}(mg/ml) *A. californicus*	LC_{90} Selective ratio*
Organophosphates			
Ethion	—	0.035	—
Prothoate	—	0.025	—
Dialifor	—	0.23	—
Dimethoate	19	0.053	358
Omethoate	1.36	0.0072	189
Organochlorine Compounds			
Dicofol	4.4	1.54	2.9
Benzomate	22.48	10.69	2.1
Chloropropylate	1.14	0.53	2.2
Dinitro and Nitrogen-containing Compounds			
Binapacryl	1.06	1.51	0.7
Formetanate	0.26	0.056	4.6
Dinobuton	0.091	0.38	0.2
Organofluorine Compound			
Nissol ·	9.42	0.66	14.3
Organic Sulfurs and Heterocyclic Compounds			
Smite	13.1	14.4	0.9
Propargite	6.81	39.41	0.2
Oxythioquinox	10.44	5.69	1.8
Organobromine Compound			
Bromopropylate	0.59	1.28	0.5
Organotin Compounds			
Cyclohexatin	—	91.92	—
Azocyclotin	8.67	8.04	1.1
Fenbutatin-oxide	—	—	—
Carbamates			
Oxamyl	1.17	0.098	11.9
Carbaryl	—	0.35	—
Synthetic Pyrethroids			
Permethrin	4.42	0.68×10^{-3}	6,500
Decamethrin	2.23	—	—
Cypermethrin	0.88	1.41×10^{-3}	624
Danitol	0.19	0.78×10^{-3}	243
Flucythrinate	6.32	6.03×10^{-3}	1,048
Fenvalerate	4.17	1.05×10^{-3}	3,971

*LC_{90} of *T. urticae*/LC_{90} of *A. californicus*.

存子代亦以同樣方法飼育及篩選。

結　　果

殺蟎劑對二點葉蟎及捕植蟎之毒性如表 2 、表 3 。不同類型殺蟎劑對兩種蟎類毒性差異很大。有機磷劑 (organophosphates) 對二點葉蟎已失去效果，對天敵卻有很高的毒性。LC_{50} 選擇比 (LC_{50} selecitve ratio) 從 193倍至1,667倍。氨基甲酸鹽類 (carbamates) 的 oxamyl 選擇比只有 10.7 倍，屬於同類的 carbaryl 卻高達123倍以上。合成除蟲菊類藥劑 (synthetic pyrethroids) 對二點葉蟎藥效以 danitol 最好。除了 flucythrinate 之外，其餘除蟲菊類藥劑 LC_{50} 值在 0.26mg/ml 至0.5mg/ml 之間。此類藥劑與有機磷劑相似，對捕植蟎毒性極高。

其餘 6 類殺蟎劑對二點葉蟎毒效彼此差異很大。如 cyclohexatin, fenbutatin-oxide LC_{50}值超過 10mg/ml ，而 formetanate 及 dinobuton LC_{50} 值只有 0.068mg/ml 及 0.059mg/ml（表 2）。這 6 類殺蟎劑對二點葉蟎及捕植蟎的 LC_{50} 選擇比都在 4 倍以下。甚至如 bromopropylate, binapacryl, dinobuton, propargite, oxythioquinox, smite 及 azocyclotin 等 7 種殺蟎劑對捕植蟎之成蟎反比對二點葉蟎安全。以 LC_{90} 值比較藥劑對二點葉蟎及捕植蟎之毒性（表 3），可以發現，binapcryl, dinobuton, smite, propargite 及 bromopropylate 五種藥劑之 LC_{90} 選擇比小於 1。此五種殺蟎劑在緊急防治二點葉蟎，提高使用濃度時，不致於將捕植蟎全數毒殺。

和 TARI 品系二點葉蟎相比，TAHU 品系二點葉蟎對殺蟎劑都有不同程度的抗藥性產生（表 4）。對 cyclohexatin, fenbutatin-oxide, formetanate 抗性程度最高。儘管 formetanate,

表4. 大湖品系二點葉蟎對殺蟎劑的抗性程度

Table 4. Resistant ratio of two strains of twospotted spider mite to acaricides.

Acaricide	LC_{50}(mg/ml)		Resistant ratio*
	TARI	TAHU	
Dicofol	0.24	1.33	5.5
Benzomate	1.16	4.93	4.3
Chloropropylate	0.21	0.38	1.8
Binapacryl	0.041	0.22	5.4
Formetanate	0.0062	0.068	11
Dinobuton	0.023	0.059	2.6
Nissol	0.71	1.02	1.4
Smite	0.29	2.0	6.9
Propargite	0.35	2.27	6.5
Oxythioquinox	0.58	1.01	1.7
Bromopropylate	0.21	0.26	1.2
Cyclohexatin	0.89	>16	>18
Azocyclotin	0.47	1.63	3.5
Fenbutatin-oxide	0.56	>10	>17.9

*LC_{50} of TAHU strain/LC_{50} of TARI strain.

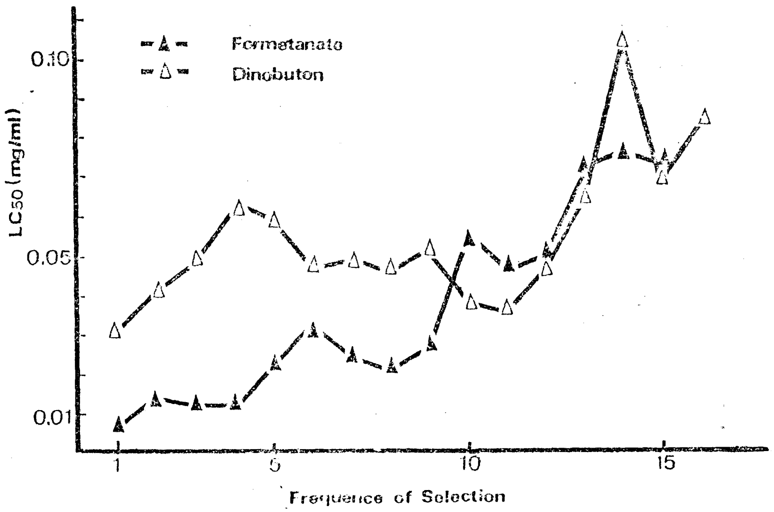

Fig. 1. Development of resistance to formetanate and dinobuton in two-spotted spider mites (TARI strain).

圖1. TARI 品系二點葉蟎對 formetanate 和 dinobuton 抗藥性產生情形

dinobuton 仍是最有效的殺蟎劑，TAHU 品系二點葉蟎對其已有相當程度的抗性。室內篩選二點葉蟎的結果（圖1）亦指出二點葉蟎很容易對 formetanate 產生抗藥性，對 dinobuton 則較不易誘發出抗性。此結果和 TAHU 品系葉蟎抗性產生情形相符。

討　論

合成除蟲菊類藥劑（synthetic pyrethroids）對於落葉果樹葉蟎之天敵具有極高毒性，相反的，在相同濃度之下卻不見得對害蟎有效[7]。Hoyt et al. 指出施用 permethrin 的濃度和二點葉蟎密度升高有關。更由於施用這類藥劑使西方捕植蟎（*Typhlodromus occidentalis*）密度急劇降低，無法有效控制葉蟎，引起葉蟎大發生[12]。此外，使用 fenvalerate 也會改變二點葉蟎取食行爲，形成忌避現象[10]。

表2與表3所列合成除蟲菊類藥劑，對二點葉蟎和加州捕植蟎選擇比在所用各類型藥劑中最高，達31,000倍（decamethrin）（表2），其餘也高至千倍，最低者（danitol）亦有255及243倍。顯示所選用的除蟲菊藥劑，由綜合防治的觀點來看，並不適用於防治二點葉蟎。Permethrin 與 cypermethrin 化學結構近似，對二點葉蟎 LC_{50} 值相近，但對天敵 LC_{50} 選擇比由3600倍劇降至764倍。Hall 的報告也指出 fenpropanate, fenvalerate 對歐洲葉蟎（*Panonychus ulmi* (Koch)）藥效差異甚大[10]。Plummer et al. 將除蟲菊藥劑結構稍加改變，證明能提高對二點葉蟎的毒性[14]。有機磷劑的 dimethoate, omethoate 化學結構只是 s=P< 和 o=P< 的差異，對葉蟎藥效差異也很大（表2）。這些結果說明一些對天敵毒性强或對葉蟎無效的殺蟎劑可以經由化學結構上的些許改變以增加對葉蟎毒效、降低對天敵毒性。

二點葉蟎對有機磷殺蟎劑如 ethion, prothoate, dialifor 已經有很强的抗藥性，導致二點葉蟎及加州捕植蟎之間有百倍以上的選擇比值（表2、表3）。羅及趙報告指出二點葉蟎對有機磷劑產生抗藥性以及有機磷劑對天敵强烈毒殺作用，是二點葉蟎猖獗的可能原因[4]。

氨基甲酸鹽類中 oxamyl LC_{50} 選擇比只有10.7倍。carbaryl 的選擇比却高達123倍以上，且對二點葉蟎沒有防治效果。由於有機磷類，氨基甲酸鹽類藥劑是防治害蟲的主要藥劑類型，大量使用的結果，很容易因葉蟎產生抗藥性，造成亞致死效果（sublethal effect）[7]，因而改變葉蟎繁殖潛能[5]及毒殺天敵的雙重影響，使葉蟎常有再猖起（resurgence）的現象。

除了上述三類藥劑，其餘類型殺蟎劑對二點葉蟎及加州捕植蟎毒性接近。顯示若在適當的使用之下，將較能把葉蟎及其天敵棲羣調整至適當的比例。

Cyclohexatin 在世界各地用於防治害蟎，具有對害蟎毒性高對天敵低毒的性質。Croft et al. 指出 cyclohexatin 自 1970 年代使用至今，並未產生抗藥性問題，部份的原因是配合綜合防治限制 cyclohexatin 的施用次數及濃度[8]。若未能配合綜合防治方法將很容易使葉蟎對 cyclohexatin 產生抗藥性[11]。大湖地區二點葉蟎對 cyclohexatin 突出的抗性程度（表4），顯示以往該地區曾長期而大量地使用 cyclohexatin 防治二點葉蟎。

azocyclotin, cyclohexatin 是化學結構類似的有機錫劑（organotin), azocyclotin 尙未在本省田間使用。TAHU 品系葉蟎對其有近4倍的耐藥性產生，明顯是由於對 cyclohexatin 的交互抗性所致（表4）。

室內篩選結果如圖一。若和原始濃度相比，二點葉蟎分別產生 11.8 倍（對 formetanate）、2.5倍（對 dinobuton）抗性，證明二點葉蟎對 formetanate 抗性產生速度較快，和田間結果一致。TARI 品系對 formetanate LC_{50} 値爲 0.0062 mg/ml（表3）和加州捕植蟎選擇比只有0.3倍，然而由於 TAHU 品系二點葉蟎對 formetanate 產生抗藥性，使二者選擇比躍升爲3.6倍（表2），遂不利於天敵的生存。dinobuton 較不易誘發出二點葉蟎抗藥性，且對天敵毒性亦低，可以作爲基本防治藥劑之一，配合其它方法以防治二點葉蟎。formetanate 雖然在目前對二點葉蟎有最

好的藥效，但長遠看却不是可以信賴的理想藥劑。Croft et al. 也由抗性遺傳證據指出 formetanate 不能取代 cyclohexatin 及其它殺蟎劑[8]。除非能建立一套合理防治方法，否則 formetanate 無法長期有效的防治二點葉蟎。

運用天敵及殺蟎劑進行葉蟎綜合防治是很可行的防治方法，可以有效減少因用藥引起的各種不良影響，又可維持作物不受蟎害確保產量。天敵對藥劑的忍受能力一般不如二點葉蟎，同時天敵對藥劑抗性產生能力也因食餌的限制，不易發展出抗藥性[6]。因此在選用藥劑時，須以對天敵毒性低者爲優先。此外，尙須考慮葉蟎對殺蟎劑抗性產生的速度，避免爲了維持殺蟎效果，不斷提高用藥濃度，使天敵遭受毒害或使害蟎產生亞致死反應而引起再猖獗現象發生。

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Selectivity of Acaricides to Two-spotted Spider Mite, *Tetranychus urticae* Koch and the Predatory Mite, *Amblyseius californicus* (McGregor)[1]

Tze-kann Wu, Shiang-ru Lin and Kang-chen Lo[2]

Summary

The responses of two-spotted spider mite, *Tetranychus urticae* (Koch) and their predator, *Amblyseius californicus* (McGregor) to acaricides tested were different. The selective ratio between the spider mite and predatory mite was depended on the chemical structure of acaricides. Generally, synthetic pyrethroids, organophosphates and carbamates are more toxic to the predatory mite than to two-spotted spider mite, and resulted high selective ratios. Other groups of acaricides stated safer to the predatory mite, usually, the LC_{50} selective ratios were less than 4.

Six acaricides i. e. bromopropylate, binapacryl, dinobuton, propargite, oxythioquinox and smite showed effective control to the two-spotted spider mite, and less harmful to the predatory mite, the LC_{50} selective ratio were less than 1. These acaricides can be used as agents for the integrated control of mite pests.

Formetanate and dinobuton are the two most effective acaricides that we used in this treatment for the two-spotted spider mite control. While after 15 and 16 generation of selections, two-spotted spider mite developed 11.8 and 2.5 folds of resistance to formetanate and dinobuton, respectively. Two-spotted spider mite showed ability in rapidly developing resistance to formetanate, so this acaricide should be carefully used in the field.

The chemical structure of azocyclotin is similar to cyhexatin. Field two-spotted spider mite have showed 3.5 folds of resistance to the former, although azocyclotin has not been used in Taiwan before. The insensitivity may due to the cross-resistance from cyhexatin, since azocyclotin and cyhexatin are very similar in their chemical structure.

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A New Species of Neoneurinae (Hymenoptera: Braconidae) from Taiwan[1]

Liang-yih Chou[2]

Abstract: *Elasmosoma taiwanense* sp. n. (Braconidae: Neoneurinae) from Taiwan is described and illustrated.

Neoneurinae is a small subfamily, containing endoparasitoids of adults of worker nts. it consists of the genera *Elasmosoma*, *Euneoneurus*, *Neoneurus* and *Parelasmosoma*. *Elasmosoma* previously included only 11 species in the world. In this paper a new species from Taiwan is added to the fauna of the world. The type specimens of this species are doposited in the insect collection of the Taiwan Agricultural Research Institute, Taichung, Taiwan.

Elasmosoma taiwanense Chou, sp. n.

Female: Head 1.18 times broader than mesonotum. Face 1.25 times as high as its breadth; face and clypeus (fig. 2) transversely strigose; frons and vertex (fig. 3) reticulate-coriaceous with transversely strigose element particularly upon vertex between and around ocelli. Malar space very short, 0.13 times as long as eye height. Distance between hind ocelli 0.75 times distance between hind ocellus and eye. Distance between hind ocellus and eye 2.40 times width of hind ocellus. Antenna 13-segmented (fig. 10).

Pronotum reticulate-coriaceous to strigose. Mesonotum (fig. 6) reticulate-coriaceous. Mesopleurum and metapleurum (fig. 7) reticulate-coriaceous with rugulose element; lateral areas of scutellum and metanotum canaliculate. Propodeum (fig. 4) strongly reticulate-rugose. Costa of fore wing thickened. Stigma wide and reflexed anteriorly into a pouch-like fold (fig. 8). Tarsus of fore leg 0.87 times as long as tarsus of middle leg. Basitarsus of middle leg almost as long as tibial spine and 1.29 times as long as tarsal segment 2. Inner spur of hind tibia 0.78 times as long as hind basitarsus.

Abdomen 0.90 times as long as head and thorax together (fig. 1). Tergite 1 (fig. 9) almost as long as apical width, reticulate-rugose. Tergite 2 and 3 (fig. 9) 0.56 and 0.63 times as long as apical width, respectively; punctate reticulate. Tergite 4 and the following tergites slightly reticulate-coriaceous. Hypopygium (fig. 5) deeply notched distally.

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Blackish; clypeus dark brown; mandible yellowish brown (except apex brown); tergite 2 and the following tergites more or less lighter. Wings hyaline; veins yellowish brown; costa, metacarpus and stigma dark brown. Legs yellowish brown ; 5th tarsi and claws darker.

Length: Body, 2.33 mm; antenna 0.89 mm; fore wing, 1.87 mm; ovipositor sheath, 0.16 mm.

Male: Antenna 14-segmented, longer and thicker than female (fig. 11). Coloration darker than in the female.

Specimens examined: Holotype: ♀, Tungpu 1200m, Nantou, 18-23. XI. 1981 (T. Lin & W. S. Tang). Allotype: ♂, same data as holotype. Paratypes: Meifeng 2150m, Nantou, 1♂, 5-9. X. 1980; Wushe 1150m, Nantou, 1♂, 6-11. V. 1981 (K. S. Lin & S. C. Lin); & Tungpu 1200m, Nantou, 1♂, 25-29. IX. 1980 (L. Y. Chou & T. Lin).

This new species keys to *Elasmosoma berolinense* Ruthe in the key to species of *Elasmosoma* (Huddleston, 1976). It can be readily separated by the shape of hypopygium.

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臺灣蟻繭蜂亞科 (Neoneurinae) 之一新種

(膜翅目：小繭蜂科)[1]

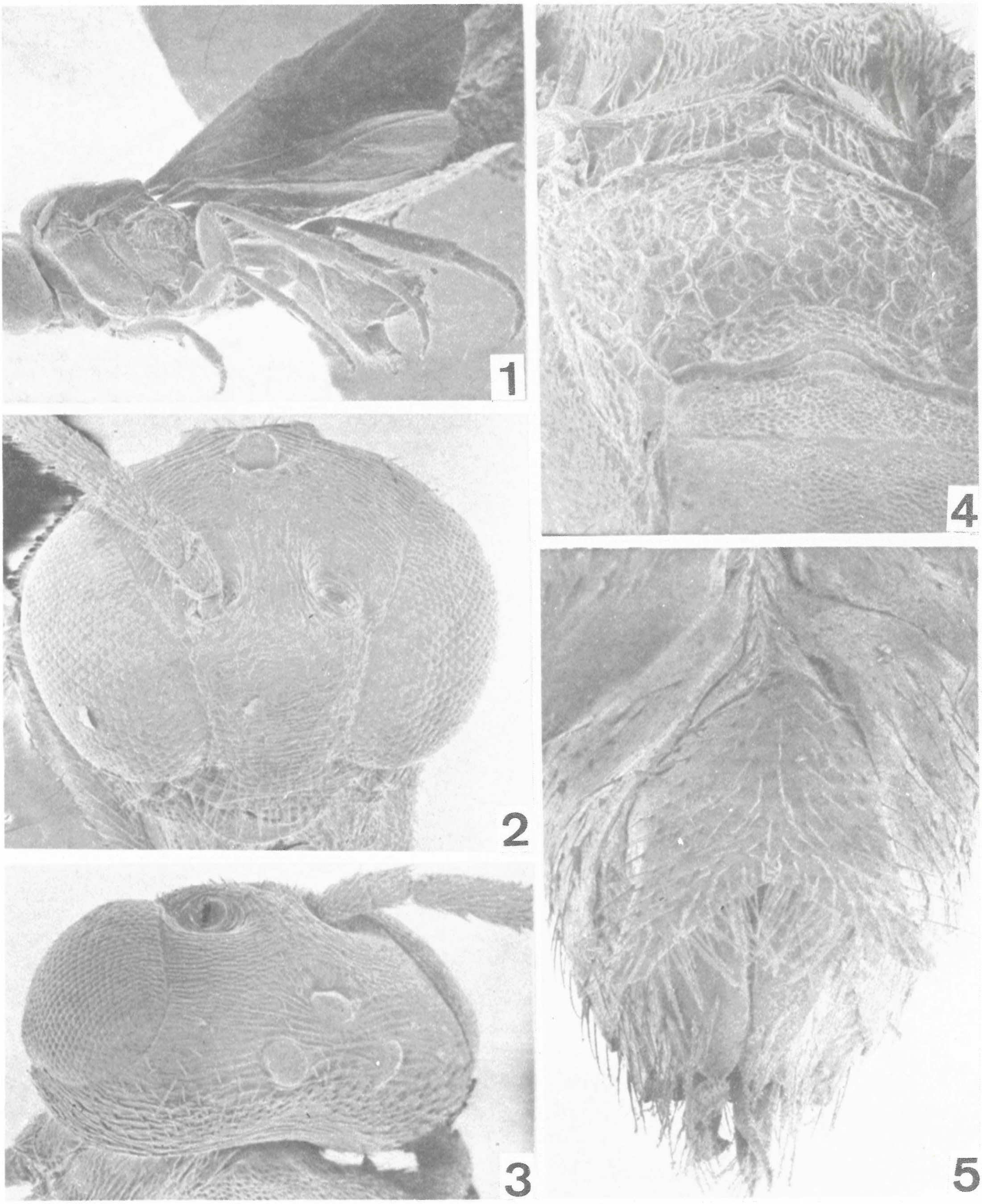
周 樑 鎰[2]

摘 要

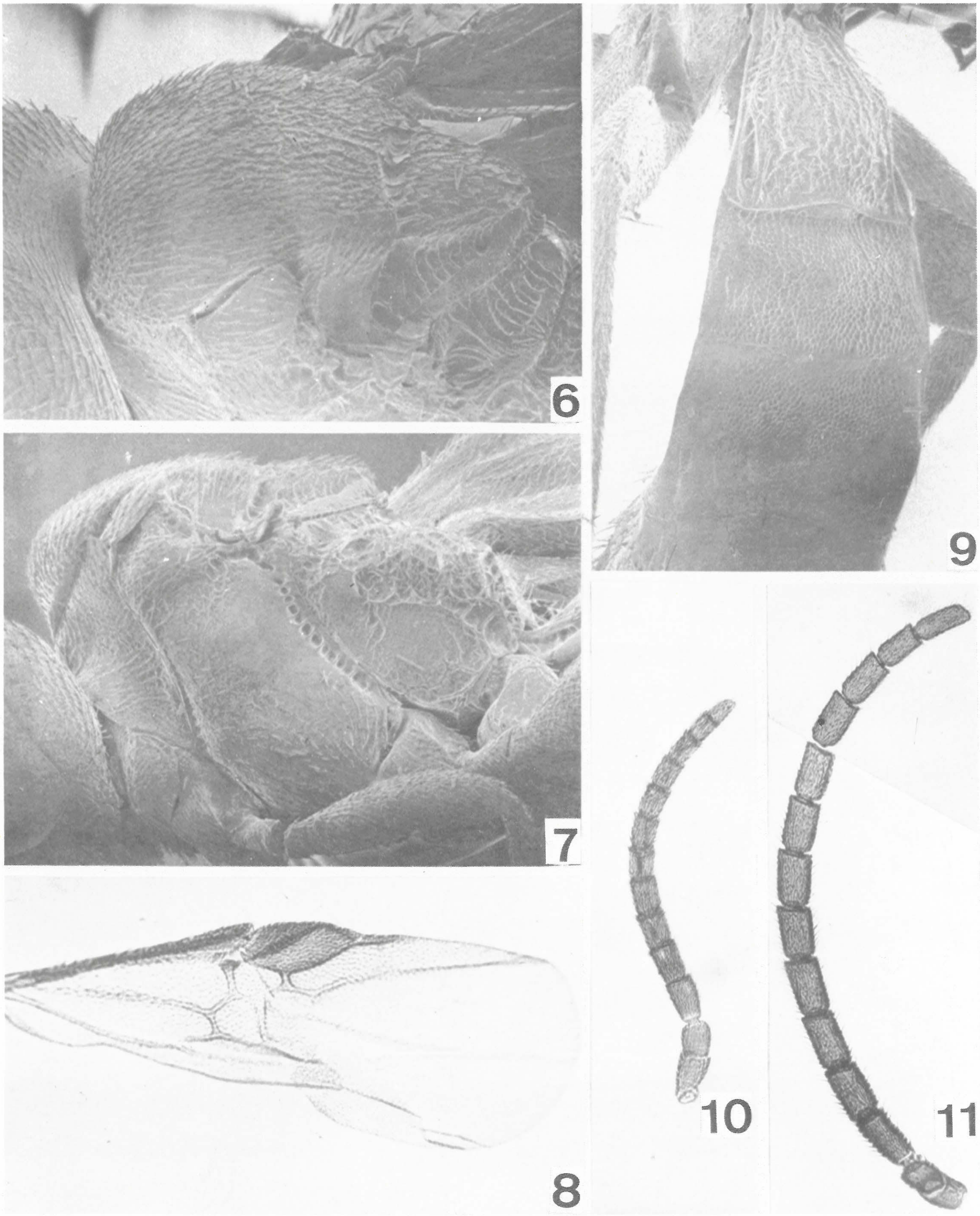
蟻繭蜂亞科之種類為螞蟻之寄生蜂，目前全世界已知之種類約有 4 屬20種。該亞科為臺灣之新記錄，本文描述臺灣蟻繭蜂 (*Elasmosoma taiwanense* Chou，新種) 之形態特徵，並輔以照片說明。

1.臺灣省農業試驗所 研究報告第 1250 號

2.本所應用動物系助理研究員。臺灣省 臺中縣 霧峰鄉。



Figs. 1–5, *Elasmosoma taiwanense* sp. n., holotype: 1, lateral view of whole insect; 2, frontal view of head; 3, dorsal view of head; 4, dorsal view of propodeum; 5, ventral view of hypopygium.



Figs. 6-11, *Elasmosoma taiwanense* sp. n. Figs. 6-10, holotype: 6, dorsal view of mesonotum; 7, lateral view of thorax; 8, fore wing; 9, dorsal view of basal part of abdomen; 10, antenna. Fig. 11, Allotype: antenna.

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